PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

ENGINEERING EDUCATION

VOLUME 59

1951–52

PUBLICATION COMMITTEE:

F. M. DAWSON, S. C. HOLLISTER, A. B. BRONWELL (EDITOR)

OFFICE OF THE SECRETARY

EVANSTON, ILLINOIS

1952

LANCASTER PRESS, INC., LANCASTER, PA.

Solomon Cady Hollister, President, A.S.E.E., 1951-52

The newly elected President of the Society has been engaged almost equally in both the practice and the teaching of engineering. Although the past twenty years have brought him a succession of academic assignments, culminating in his appointment as Dean of the College of Engineering at Cornell University in 1937, he has continued in this period his early association with professional practice and development. His concern with the advancement of the engineering profession is evident in his expressions of educational philosophy, particularly in his insistence that today's education must be strengthened to support the advanced technology of two or three decades hence.

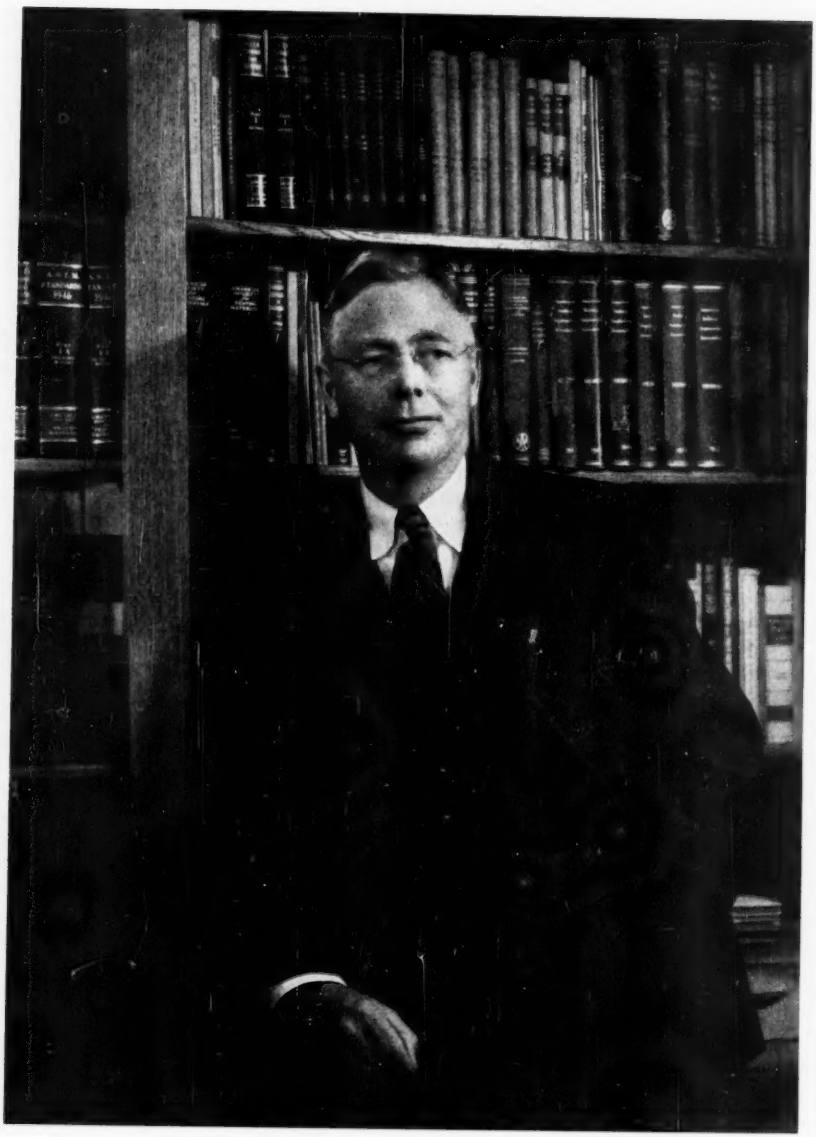
Dean Hollister's own collegiate training was undertaken at the State College of Washington, and at the University of Wisconsin, where he received the B.S. in C.E. in 1916 and the C.E. in 1932. He was awarded the honorary degree of Doctor of Engineering at Stevens Institute of Technology in 1942.

For a period of fifteen years after graduation he engaged in a wide range of professional practice. It was at this time that reinforced concrete construction was emerging from the status of a somewhat unpredictable art to that of a structural science. Dean Hollister soon became associated with several of the major activities in this field, including in his work the post of chief design engineer on the development of concrete ships for the U. S. Shipping Board in World War I. Although his career has since taken him into various other engineering interests, he has maintained a close affinity with concrete technology as a teacher, consultant, and member of numerous technical groups in the field. He has served as a member of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete. His long association with the American Concrete Institute includes several committee chairmanships and two terms as president, 1932–34.

Of his many publications, a good number deal with concrete and structural design, including A.C.I. Wason Research Medal paper, "Design and Construction of a Skew Arch Bridge." He has also contributed sections on these subjects for several engineering handbooks.

As a consulting engineer in the 1920's, he became interested in the potentialities and problems of structural welding. He undertook the development of the more rigorous methods of stress analysis and engineering control required in welded fabrication. This interest in turn led him back to the academic scene at Purdue where, in 1930, he accepted appointment as Professor of Structural Engineering and Assistant Director of the Testing Materials Laboratory. His work on photoelastic methods of analysis led to his appointment as consulting engineer to Babcock and Wilcox on the design and fabrication of the Hoover Dam penstocks. He has since carried out a number of assignments for this company on high pressure boiler design. Other consulting activities with industry and government agencies have covered a wide range of engineering problems.

In 1934 he came to Cornell as Director of the School of Civil Engineering, and in 1937 he was appointed Dean of the College of Engineering. He has since devoted much time to educational



SOLOMON CADY HOLLISTER, PRESIDENT

development, and particularly to the relation of engineering education to the profession. For the past two years he has been chairman of the Education Committee of Engineers' Council for Professional Development, and chairman of the Subcommittee on Graduate Education. His affiliation with A.S.E.E. dates back to 1916 and includes service as chairman of the Administrative Division (S.P.E.E.) and of the Committee on Universal Military Training (S.P.E.E.), member of the Manpower Committee, and member of Council (1937–40).

For the past several years Dean Hollister has been active in focusing attention on the impending shortage of engineers. He is presently serving as a member of the Engineering Manpower Commission of Engineers Joint Council; the Advisory Committee on Engineering Sciences for Selective Service; and the Committee on Specialized Personnel, Office of Defense Mobilization.

Dean Hollister is a member of a number of professional societies, including A.S.C.E., which he served as a director, A.S.M.E., A.R.E.A., and others, and of Sigma Xi, Tau Beta Pi, Phi Kappa Phi, Chi Epsilon, and Gamma Alpha. His public service has included the chairmanship of the Advisory Committee on Water Resources of the State of New York; membership on the Governor's Advisory Committee on Technical Industrial Development; consultant to the U. S. Maritime Commission; and Regional Director for ESMWT during the war years. He is at present a member of the Advisory Committee to the U. S. Coast Guard Academy.

Fall Meetings **Fall Meetings**

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

including

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL
ENGINEERING COLLEGE RESEARCH COUNCIL
GENERAL COUNCIL

November 15, 1951 **Rice Hotel, Houston, Texas**

The ECAC along with the ECRC and the General Council will hold meetings at the Rice Hotel, Houston, Texas, Thursday, November 15, at 2:00 P.M. These meetings will immediately follow the annual meeting of the Association of Land-Grant Colleges and Universities, which will be held at the Rice Hotel from Monday, November 12, until Thursday noon, November 15, inclusive. This arrangement is for the benefit of many of our members who also belong to the Land-Grant College Association.

President Hollister will open the meeting, outlining the need for such guidance activity.

The Year of Evaluation

By S. C. HOLLISTER

President, ASEE and Dean of Engineering, Cornell University

It seems appropriate, in this first year of the second half of this century, that we take account of our progress in engineering education through an objective evaluation of our performance; and that we appraise the engineering profession to determine whether its growing needs are being adequately met.

Fifty years ago, at the turn of the century, the steam turbine was just emerging. Although electricity was an established source of power, it had not yet gained its eventual place in industry; and the household appliance was far in the future. The automobile was scarcely to be trusted on a trip the length of Main Street, and if one wished to venture farther, he found there were no decent roads. The X-ray was very new and the airplane and radio-telegraph were yet to come. The telephone was a box on the wall. Kerosene was still widely used for lighting. The petroleum and chemical industries were only beginning. The first steel bridge was about twenty years old.

Although there were at that time about 110 schools teaching some phases of engineering, only a few would be considered as being strong. There had emerged by that time, however, the general form of curriculum that during the following decade became generally adopted. That these early curricula furnished strong support for the profession in bringing into being the many engineering achievements of those times is understandable, since these achievements were largely first approximations, made with a wealth of natural material resources upon which to draw. Because of their widespread adoption as to both form and content, these curricula became standard; and certainly in the older branches of civil, mining, mechanical and electrical power engineering, the curricula have in most schools been modified very little in the last forty years.

The educational system that has come into being in this country certainly was not evolved after a preconceived national plan, so far as engineering and allied fields are concerned. Whereas abroad there is commonly a technical institute program functioning in parallel with strong professional engineering education, there have been relatively few technical institutes in this country, leaving the burden of serving both needs upon the engineering schools. Moreover, engineering curricula developed as substitutes for, rather than extensions of, general collegiate education, and thus did not follow the evolution of education in the medical and legal professions.

During the periods between the two world wars the engineering schools were preoccupied with problems arising from this process of substitution. There was general agreement that more general education was needed. There were border fields into which some engineering graduates were going, such as management and commerce. It seemed to some that the engineering curriculum should somehow be made to stretch over all this range of education—and at the same time the length of the programs must not go beyond the traditional four years.

Some doubted the wisdom of trying to make the engineering curriculum serve so many objectives in so limited a time. It took the urgent demands of World War II to bring into focus once again

the fact that the *primary* function of the engineering school is to train engineers, and train them well.

And now, at this mid-century point, it is pertinent to ask some questions of ourselves. Just how well are we preparing engineers? Are we training them to perform a certain list of skills, or are we educating them in the fundamentals of a profession and inspiring them toward further self-development after "commencement"? Just how thoroughly and extensively are we giving them these fundamentals; and in the light of scientific advances are we giving them all they will need twenty-five years after they leave us? Have the technical needs of industry and the profession advanced and will they further advance during the next quarter century? Shall we be satisfied with a curriculum that was largely crystallized forty or more years ago, and if so, how can we make it serve? Should we look to scientists to enter the profession, to provide a dynamic and adequate growth?

We have but one duty: to serve the student so well that he will not be found wanting when called upon by his profession or his country. Are we performing this duty to our complete satisfaction?

I propose that we devote a major portion of our time during this year to a searching inquiry into these and other questions in the hope that as a Society we shall further advance our profession, in the interest of the progress of the students we serve.

In the News

New Issue of ECPD Guidance Manual Published

A guidance manual intended for engineers who are aiding young men interested in the engineering profession was recently published by the **Engineers' Council for Professional Development**, 33 W. 39th St., New York, N. Y. The 15-page pamphlet, prepared by the ECPD Guidance Committee, urges members of local engineering societies and sections and chapters of national engineering societies to establish guidance committees to aid high school pupils to determine whether they are qualified for careers in engineering. The present critical engineering manpower shortage emphasizes the need for guidance of the type indicated in this manual. The manual explains briefly how to organize advisory committees and how to select committee members. The manual contains suggestions for working with high schools and secondary schools students and lists aids especially useful in counseling high school boys. The guidance manual is supplemented by an appendix, "Shall I Study Engineering?" which is a questionnaire to be filled out by the student for use of the engineer who is advising him.

Is Less Than Graduation Worth While?*

By CLEMENT J. FREUND

Dean, College of Engineering, University of Detroit

"Well, good-bye, my boy. It's too bad it turned out this way. But pick up your courage; you have been working hard, and hard work will get you there, one way or another. Make a new start and your luck ought to be better. And best wishes, wherever you go and whatever you try."

There can hardly be a faculty man in the room who has not time and again gone through the painful business of shaking hands with a student who is quitting college. Perhaps the study of engineering has been the student's absorbing ambition ever since he was a small boy. Possibly his parents have spent their lives hoping, planning and working "to get him through" the college of engineering. He is sure to be a pathetic if not a tragic figure.

We engineers and engineering educators have always been concerned about the student who "drops out" or is "kicked out." The Report of Investigation of Engineering Education deplored the plight

"of the eighteen-year-old boy just emerging with his fondest dreams dashed to pieces, after his first disastrous experience with the elimination machine. . . ."[1]

And the Engineers' Council for Professional Development, in the Fifth Annual Report, insists that

"moral and psychological effects of failure are serious and real. The sense of defeat is a handicap at a critical period in the life of youth struggling for a foothold."[2]

Terminal Character of Faculty Concern

But if we take a good look at our concern for the student who is dropping out, we have to admit that it has what might be called a terminal quality. We are genuinely sorry because he will not graduate, but we quickly wash our hands of him the moment he departs. True, we are logical enough; it is our job to teach engineering students, and we can't teach them after they have gone. But our very logic puts to shame the boy who does not graduate, and marks him as a second-rater. Anybody who has doubts in the matter need only listen to the embarrassed, frantic apologies of the lad who has dropped out; or of his parents.

Furthermore, because the engineering curriculum of four or five years is an integral unit, we make it appear to the student, his parents and the public, that it has to be all or none, and that if he gives up after two or three years, he has utterly wasted so may years of his precious young life.

On the face of it, does not all of this seem wrong? Can anyone seriously contend that the student gains nothing whatever from learning, or trying to learn, the subject matters of even the freshman year, and from exercising the diligence, patience and determination which the learning process requires? Surely, the engineering student does not acquire all the values of a college education during the commencement exercises, as if in a package with his diploma; he absorbs them gradually as he goes along.

Besides, is it not altogether possible that there are students who should not go on to graduate? For all we know, two or three years of study may be more

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* Presented before the ECAC at the Annual Meeting of the ASEE, Lansing, Michigan, June 28, 1951.

[1] Society for the Promotion of Engineering Education, I, 208.

[2] (October, 1937) p. 11.

profitable and appropriate to their temperaments, talents, plans and career objectives. Indeed, I am personally acquainted with a number of gifted and highly successful men who completed only two years of the engineering curriculum, and never did intend to complete more.

Faculty Interest

The Engineering faculty in the University of Detroit has been much interested in all these conjectures—and conjectures are all that they have been. Some months ago we determined to find out, if we could, from non-graduating former students (hereafter called "former students") just what they think about the fragmentary education they have had. We mailed a carefully worded letter and a report form to approximately one in ten former students, selected at random from those who have left the University since 1930. The report form was really a questionnaire, but the word is in such evil repute that we used a different term.

We distributed 986 report forms, and 146 were returned undelivered. Hence, 840 former students presumably received the forms. 226 of these 840, or 29.6 per cent, filled out the reports and sent them back to us.

Questions

We proposed to ourselves a number of questions which bear on the problem of former students. These questions follow, together with data which the former students supplied in answer to each, and brief comment where comment appeared to be called for.

How many years of the curriculum did the former students complete? (Table 1)

TABLE 1

All Reporting Former Students. Percentage Distribution by Years of Curricular Completed

Completed one year	22.5%
Completed two years	47.8
Completed three years	18.6
Completed four years	8.4
Completed five years (Five year curricula in University of Detroit)	2.2
Completed more than five years	0.5

Did the former students learn enough in the university to make their studies, time, and tuition and fee payments worth while? (Table 2)

TABLE 2

All Reporting Former Students. Percentage Distribution by Opinion Concerning Value of Studies

Studies worth while	77.4%
Studies not worth while	17.3
No answer	5.3

This is obviously the very core of the discussion. What we really want to know is not if college studies did the former students any good (they could hardly harm them), but whether they would spend the time and the money if they had it to do over again.

These former students do not support the more or less common opinion among both teachers and students that those who fail of graduation have wasted all the months and years they spent in college.

Have their college studies been of use to the former students in their present employments? (Table 3)

TABLE 3

All Reporting Former Students. Percentage Distribution by Opinion Concerning Value of Studies in Employment

Studies useful in employment	80%
Studies not useful in employment	16
No answer	4

We looked for this kind of result. Preparation for employment is, of course, one of the principal objectives of engineering education, and it should be no surprise to find that the majority of the former students have profited in their

jobs from even a portion of the curriculum.

In what kind of work are those former students engaged who reported that their college studies have been of use in their present employments? (Table 4)

TABLE 4

Former Students Whose Studies Are Useful in Employment. Percentage Distribution by Kind of Work

Engineering or technical, such as testing, estimating, heat treating, surveying, etc.	44%
Manufacturing or construction, such as production, contracting, maintenance, operating, inspection, time study, etc.	18
Business or commercial, such as bookkeeping, selling, advertising, banking, financing, etc.	20
Armed forces	5
Employment other than preceding	9
Unemployed	4

These data should raise questions in the minds of those of us who tell the student who is going to quit that he ought to stay out of technical and industrial occupations, and should "try banking or journalism or something."

What percentage of all former students engaged in each kind of work have found their college studies of use in their employments? (Table 5)

TABLE 5

All Reporting Former Students. Percentage in Each Kind of Work Who Reported Studies of Use in Their Employments

Engineering or technical, such as testing, estimating, heat treating, surveying, etc.	99%
Manufacturing or construction, such as production, contracting, maintenance, operating, inspection, time study, etc.	89
Business or commercial, such as bookkeeping, selling, advertising, banking, financing, etc.	71
Armed forces	75
Employment other than preceding	64

It is noteworthy that former students consider their studies more or less useful according as technology is relatively more or less important in the kind of work they are doing.

Is the value of college studies in their employments affected by the number of years of the curriculum the former students completed? (Table 6)

TABLE 6

All Reporting Former Students by Years of the Curriculum Completed. Percentage Completing Each Year Who Reported Studies of Use in Their Employments

Completed one year	69%
Completed two years	84
Completed three years	81
Completed four years (Five year curricula in University of Detroit)	89

This is exactly what one would expect; studies are useful in employment approximately in proportion to the length of time spent in college. The logical inference, of course, is that it is better for the student to graduate than not to, as far as his job is concerned. But the issue here is whether less than graduation is of any value at all.

Just how have college studies been of use to former students in their employments? (Table 7)

TABLE 7

Former Students Whose Studies Are Useful in Employment. Percentage of Total Reporting How Studies Have Been of Use

Understanding of the principles of the physical sciences, mathematics, chemistry, physics	71%
Skill in drafting, computing, testing, use of instruments, etc.	58
Information about techniques, organization and practices of engineering, manufacturing, construction, etc.	38
Habits of accuracy and thoroughness, method of thinking, creative ability, etc.	71
Other than preceding	28

These data were especially pleasing to our faculty. If we have had any special and favorite purposes, these have been to impart comprehension of scientific principles and good work habits to the students, and the former students report that it is these purposes which we have most successfully accomplished.

HAVE THE FORMER STUDENTS BEEN HELD BACK IN THEIR EMPLOYMENTS BECAUSE THEY HAVE NO COLLEGE DEGREE? (Table 8)

TABLE 8

ALL REPORTING FORMER STUDENTS. PERCENTAGE DISTRIBUTION ACCORDING TO HANDICAP IN EMPLOYMENT BY LACK OF DEGREE

Held back by lack of degree	24.8%
Not held back by lack of degree	68.6
No answer	6.6

This result seems to make it clear that most of the former students have no regrets whatever about not graduating, at least as far as their jobs are concerned. And if they were to start their lives over again they would doubtless again leave college before earning their degrees.

HAVE PASSING YEARS AND CHANGING CONDITIONS HAD ANY EFFECT UPON THE USEFULNESS OF COLLEGE STUDIES IN THE EMPLOYMENTS OF FORMER STUDENTS? (Table 9)

TABLE 9

ALL REPORTING FORMER STUDENTS BY CALENDAR YEARS IN WHICH THEY LEFT THE UNIVERSITY. PERCENTAGE LEAVING EACH YEAR WHO REPORTED STUDIES OF USE IN THEIR EMPLOYMENTS

Those leaving in 1950	74%
Those leaving in 1949	74
Those leaving in 1948	78
Those leaving in 1947	83
Those leaving in 1943	71
Those leaving in 1942	83
Those leaving in 1941	82
Those leaving in 1932	81
Those leaving in 1931	100

At first sight it may appear that the percentage of former students who profit from studies in their employments is decreasing from year to year. However, 100 per cent in 1931 may easily be some kind of "wild point," and there appears to be no significant trend since then.

Only those years were tabulated during which more than ten students have left the University.

So much for the value of college study to former students in their jobs.

Humanistic-Social Value of Studies

To prepare students for employment is an important, but by no means the only objective of engineering instruction. The undergraduate engineering student should acquire much besides specific technical competences and skills. He should obtain what we call a "humanistic-social" education to round him out as a man and a citizen.

President Harvey Davis, Dean A. A. Potter, and doubtless others, have gone so far as to insist to us again and again that an undergraduate engineering education is altogether appropriate, in this machine and industrial age, even for the young American who has no intention whatever of becoming an engineer.

We proposed a number of questions in order to ascertain if and how their college studies have been useful in the humanistic-social growth and development of our former students. These questions follow, together with report data from the former students in answer to the questions, and our own remarks.

HAVE THEIR COLLEGE STUDIES BEEN OF USE TO THE FORMER STUDENTS IN THEIR HUMANISTIC-SOCIAL DEVELOPMENT? (Table 10)

TABLE 10

ALL REPORTING FORMER STUDENTS. PERCENTAGE DISTRIBUTION BY OPINION CONCERNING HUMANISTIC-SOCIAL VALUE OF STUDIES

Studies of humanistic-social value	84%
Studies of no humanistic-social value	14.2
No answer	1.8

Most people who think about the matter at all are probably of the opinion

that to prepare for employment is the principal aim of engineering education, and that the humanistic-social aim is secondary. These former students seem to think differently. 84 per cent of them asserted that their college studies have been of humanistic-social value to them, while only 80 per cent (Table 3) found their studies of use in their employments.

IS THE HUMANISTIC-SOCIAL VALUE OF COLLEGE STUDIES AFFECTED BY THE NUMBER OF YEARS OF THE CURRICULUM THE FORMER STUDENTS COMPLETED? (Table 11)

TABLE 11

ALL REPORTING FORMER STUDENTS BY YEARS OF THE CURRICULUM COMPLETED. PERCENTAGE COMPLETING EACH YEAR WHO REPORTED STUDIES OF HUMANISTIC-SOCIAL VALUE

Completed one year	78%
Completed two years	85
Completed three years	81
Completed four years (Five year curricula in University of Detroit)	95

The former students profited in their humanistic-social development approximately in proportion to the years they spent in the College of Engineering. This just about checks with the corresponding advantage of college studies in employment (Table 6).

JUST HOW HAVE COLLEGE STUDIES BEEN OF USE IN THE HUMANISTIC-SOCIAL DEVELOPMENT OF FORMER STUDENTS? (Table 12)

TABLE 12

FORMER STUDENTS WHOSE STUDIES HAVE BEEN VALUABLE IN HUMANISTIC-SOCIAL DEVELOPMENT. PERCENTAGE OF TOTAL REPORTING HOW STUDIES HAVE BEEN OF VALUE

Understanding of the viewpoints, habits and ways of living and acting of fellow men	65.7%
Ability in speaking and writing	63.7
Understanding of right and wrong	54.2
Understanding of the problems of living together, and of social, civil and government questions, etc.	48.4
Interest in and appreciation of literary and artistic productions	31.6
Advantages not listed	34.8

63.7 per cent of the former students declared that they had learned how to express themselves. This was especially gratifying to the faculty because we hear so many and such frequent complaints that engineers can neither speak nor write effectively.

HAVE THE FORMER STUDENTS BEEN HELD BACK IN THEIR HUMANISTIC-SOCIAL DEVELOPMENT BY LACK OF A DEGREE? (Table 13)

TABLE 13

ALL REPORTING FORMER STUDENTS. PERCENTAGE DISTRIBUTION ACCORDING TO HANDICAP IN HUMANISTIC-SOCIAL DEVELOPMENT BY LACK OF DEGREE

Held back by lack of degree	6.2%
Not held back by lack of degree	88.1
No answer	5.7

As we might expect, a degree seems to be more useful in employment than in humanistic-social development. 6.2 per cent found themselves retarded in humanistic-social development by lack of a degree, while 24.8 per cent found themselves retarded in employment (Table 8).

84 per cent of the former students reported their studies useful in humanistic-social development (Table 10), while only 6.2 per cent of them felt handicapped by lack of a degree. It follows that the difference of 77.8 per cent, or more than three quarters of the former students, highly prize the schooling they did have, but consider it of no consequence that they did not graduate. They might think otherwise, of course, if they had completed the curriculum.

Does not this information at least suggest a question: have we perhaps been underrating college environment and contacts as a factor in education, as compared with the system of courses and exercises we call the curriculum?

HAVE THE PASSING OF YEARS AND CHANGING CONDITIONS HAD ANY EFFECT UPON THE VALUE OF COLLEGE STUDIES IN THE HUMANISTIC-SOCIAL DEVELOPMENT OF FORMER STUDENTS? (Table 14)

TABLE 14

ALL REPORTING FORMER STUDENTS BY CALENDAR YEARS IN WHICH THEY LEFT THE UNIVERSITY. PERCENTAGE LEAVING EACH YEAR WHO REPORTED STUDIES OF VALUE IN HUMANISTIC-SOCIAL DEVELOPMENT

Those leaving in 1950	78%
Those leaving in 1949	81
Those leaving in 1948	78
Those leaving in 1947	91
Those leaving in 1943	93
Those leaving in 1942	89
Those leaving in 1941	91
Those leaving in 1932	88
Those leaving in 1931	85

As in the case of the advantages of college studies in employment (Table 9), there appears to be no significant change from year to year.

And again, only those years have been tabulated in which more than ten of the former students have given up their studies.

Over-all Comment

We obviously could not reach every single former student in a survey of this kind, but we did want to be sure that we had a proper sample.

The 226 former students who sent in their reports are just about 2.26 per cent of nearly 10,000 who have quit the University's College of Engineering since 1930. They represent every year except two since 1930, every branch of engineering which is taught in the University and, as indicated, a variety of occupations ranging from the highly technical to the distinctly non-technical. These 226 presumably represent a cross section of former students as to economic status, mode of life, viewpoint and temperament. A large percentage of them are residents of Detroit or its environment, a distinctly industrial community. There, if anywhere, engineers can live the lives and have the experiences which are typical of their profession.

Of the former students we were able to reach, 26.9 per cent returned their reports. This is certainly excellent cooperation. In fact, such a percentage of returns from graduates might be altogether satisfactory. The graduate is ordinarily more devoted to alma mater; the man who finished only a year or two can hardly be expected to display extraordinary school loyalty.

We realize, of course, that the former students can do no more than express an opinion, and that their opinions are likely to be influenced by the mood or feeling of the moment. It is probably impossible quantitatively and objectively to measure the value of education to the individual.

We asked our former students not to sign their reports. We assume, though, that those former students who have been successful in their careers are more disposed to prepare a report of this kind than those who have not done so well. Hence, the data submitted to us may be rather more favorable than the average; and this in spite of the occasional but familiar type of critical and discontented person who seems to enjoy broadcasting his complaints.

We took all these considerations into account in formulating our conclusions.

Conclusions

We believe that the data warrant our concluding as follows:

a) A considerable percentage of non-graduating former students of our College of Engineering, probably a majority, derive benefits from completing a portion of the curriculum, both in their employments and in their humanistic-social development. The benefits are apparently sufficient to justify the time, efforts and funds which the students expend for their schooling.

b) Our faculty may well be in error when we advise withdrawing students to avoid jobs in engineering and in industry.

c) We might do well to consider reconstructing our curricula in such manner that the student shall have completed at the close of each successive year, if not of each successive semester, an integrated system of courses and studies, an ab-

breviated curriculum with limited objectives, so to speak, but a reasonably unified curriculum nevertheless.

d) We should very probably take measures to revise our traditions, policies, attitudes and procedures in order that we shall in no way reflect upon the student who is unable to graduate for one reason or another.

We propose these conclusions with some trepidation. We fear that we may incur the wrath of those—and we recognize their number and their importance—who are opposed to the doing or the saying of anything which might in any way weaken the determination of students to persevere to graduation.

We don't pretend that these are new ideas or proposals. In fact, for some years Purdue University has granted certificates to those students who leave the University without graduating. As described by Dr. F. C. Hockema, Vice President, the certificate is like a diploma in general appearance, it bears the signature of the Registrar and the seal of the University, and declares that the recipient "was enrolled as a student from . . . to . . . and successfully completed the courses listed herewith." On the back of the certificate is entered a schedule, in the manner of a transcript, of those courses which the student has successfully completed. Courses which he failed or did not complete, if any, are omitted. Officers of the University believe that the certificate should very much improve the standing in his community of the young man who did not or could not remain to earn a degree.

And as long ago as 1930, the Report of Investigation of Engineering Education suggested that

"much may be done to steady the student and to draw out his best efforts if, in the face of impending voluntary self-elimination, some nearer goal were visible. This goal might be set up in the form of certifications of the work done at the end of each stage and formal admissions to the next stage. Associateships in engineering might properly be issued at the completion of the first two years' work."[3]

While these ideas and proposals are not new, they appear to be materially strengthened and supported by the opinions of the 226 former students who participated in this project.

We undertook this investigation in order to discover how instruction, courses and curricula might better serve the non-graduating student. But we suspect that much of the information may be utilized, likewise, for improving our teaching of those students who do graduate.

All of you have been thinking about what happens to the non-graduating students who leave your institutions. We venture to hope that this statement of ours may arouse sufficient interest and curiosity that some of you may undertake similar investigations among your non-graduating former students. If any of you do, we shall be very grateful if you will let us see the results you obtain.

NOTE: Report forms returned by former students contain a variety of information. Readers may inquire about combinations and relations of this information other than those which appear in the tables. For this purpose, the report forms will be preserved three months following the date of this publication.

[3] Society for the Promotion of Engineering Education, *op. cit.*, I, 213.

Engineering Education—A Bridge Between Ignorance and Understanding*

By F. M. DAWSON

President, ASEE, 1950–51; Dean of Engineering, State University of Iowa

The American Society for Engineering Education has always been extremely active in furthering the interests of Engineers in their profession. It has been wise and courageous also in stressing the educational side of its twofold duty of training and at the same time educating our clientele, the students. Primarily, we are a society of educators with a special job of developing, as best we may, embryo engineers. Young men and women come to our schools and colleges directly from high school at about the age of seventeen. We would like to do more for them than we usually are able to do as teaching is limited to 144 to 156 weeks in the average four year course. Before going any further, let me point out that 144 weeks is not a long time and that all must make the utmost use of their talents if the job is to be accomplished in such a short time. Several colleges have found it necessary to extend the time of formal training to five academic years, others to four and one-half or four years and summer sessions or camps. Those operating on the cooperative plan of Engineering Education are likewise limited in time. But in any case, we as Engineering teachers had some 184,000 students of all types under our charge last year. In almost all cases, these students ranked in the upper one-half of their high school class and because of student mortality, caused by the usual consequence of adjustment to college life and to the rigorous training of an engineer, we know that less than one-half of those who began as freshmen will be graduated. All of which means that we had a selected group to start with and an even more select group at the finish of the formal courses for the various degrees.

Concerning these students, the question is always before us, "What are we trying to do and how well are we doing it?" An answer to at least part of this question will be given you later this morning in the report of our distinguished committee on the Improvement of Teaching, which has been sparked by Dr. L. E. Grinter. This is one of the major, and to me the most significant accomplishment of the Society for the year 1950–1951.

An excellent source of information concerning our problem and its answers came to me unexpectedly. Recently, I reviewed the presidential address printed in the proceedings of the ASEE and its predecessor the SPEE. If my memory had been really good I should not have been, but I *was* amazed at the excellence of these addresses. If anyone wishes to do a good turn for himself and for the Society, nothing could be better or more helpful to the teaching profession than making a compilation of these talks. The full text of some fifty-five speeches would be too long for a book, but if edited, I am sure they would form a firm foundation, particularly for beginning teachers.

* Presidential Address, Annual Meeting of the ASEE, East Lansing, Michigan, June 27, 1951.

Bridging the Gulf

In this review one prominent feature stood out above all others and it is to this that I wish to devote my remarks this morning. Many have treated engineering education as an end in itself, giving the impression that if only we were well-trained or sufficiently indoctrinated or thoroughly educated all else would follow as a matter of course. To me this is not so. I believe that education, particularly engineering education, is a method or way and not an end in itself. It is a means whereby something else may be accomplished.

Education may be likened unto a bridge spanning the gulf between ignorance and understanding. It is a way, a means of transport. It is true that in and of itself it is a material structure, but its main purpose is to be a support for a highway or a railway, in other words, a means of conveyance.

Imagine a canyon deep and wide. On one side is ignorance, dark and dismal and full of superstitions and fears. On the other side of the canyon is understanding, which includes knowledge, freedom to think and an absence of these terrible restraints on thoughts, such as the fear of ridicule, the fear of fear itself. Understanding gives a chance for the brilliant light of opportunity to show the way to better living, better mental health and freedom of religion guaranteed to all.

It is possible for a man to cross the chasm by climbing down one side, going across the treacherous rocks at the bottom and laboriously climbing up the other side. This is the way it was done of old each had to find his on way down, across and up again. Then someone threw a rope across and we had a rope bridge on which a few only could cross at a time. These few had to be hardy souls who braved the flimsy swaying span. Later, stronger and better bridges were built and they served their purpose of furnishing a way or method of progressing from ignorance to understanding. Many could now cross whereas before only individuals could go.

My main thesis, therefore, is that education is something that is a means rather than an end. In this respect it is something like money. It is valuable when properly used and dangerous when misused. It is necessary and desirable, not for itself, but the use to which it may be put. Money, at least present day money, is a medium of exchange enabling the possessor to transfer from one to another certain rights to things. Now education is to be desired, not for itself, but for the use to which it may be put. It is a medium of exchange giving to its possessor the ability to have for himself and others the wisdom of the past and a knowledge of science with its many applications. Unlike money, however, once possessed, it cannot be stolen or devaluated, but it may be misapplied just as money may be foolishly wasted.

True engineering education must look beyond the problem of teaching subject matter. This is partly because most students must be shown the way from one side of the canyon to the other. Mathematical formulas and the physical laws of the universe are not enough. The intangibles of education, such as personal characteristics, must be included. It is our job to do what we can to go beyond the usual and inculcate those features so ably described by the late President Wickenden in his article entitled "The Second Mile." For those who are not familiar with this article, I recommend it to you.

A recent article in the *New York Times* (Margaret B. Pickel, June 3rd, 1951) has the somewhat startling headline "Education is the Teacher's Job" with the subtitle "The trouble is there are so many 'experts' trying to share it, that they ignore the true expert in the field, the educator." For many years we have been asking men from industry, from business, from almost every walk of life what should we do to save our youth from all types of trouble, most of it imaginary. As a result, I agree with the article in the

Times, "and surely it must shake the layman's confidence in education to be constantly asked for advice about it. Imagine the waiting room of a doctor on the look-out for surgical suggestions, yet teachers are increasingly taking counsel from outsiders. They ask a panel of business men what they think is the most important part of an education and the business men decide that it is good personal attitudes and work habits, enthusiasm for work, neatness, good manners, tact and punctuality, listing these traits ahead of the basic skills." Have we forgotten that the traits listed are the by-products of a disciplined education and that every teacher worth his pay must consider these in his work. If he does not, then he should leave teaching because the inculcating of these qualities should be the main purpose of our profession. I believe that by diligent work this can be accomplished without sacrificing any content. If some of the "talk-type of training" which requires little thought and less preparation were omitted we would have plenty of time for real training. But it would be hard work for the teacher and frequently harder still to defend it from the purely utilitarian and repetitious get-it-quick methods long advocated by some men who ought to know better.

Lest you think that I am advocating that we as teachers should not pay attention to what our friends in industry and business say, let me enlarge a little by paying personal tribute to the several excellent surveys made by committees of this Society, as well as those made by other organizations, using properly phrased questionnaires and studies of opinion. These are necessary and have proved their value. But they must be well conceived, thoroughly organized and followed up or the results may be worse than if they had not been undertaken. Following the consensus of a good survey is something quite different from being swayed by the opinions of every man who happens to be a loud-talker, without the inhibitions of real knowledge of the subject, and who delights in character assassination by innuendo. For example, I know of one school where a fundamental course of study was altered to suit the whims of a local manufacturer of candy.

Development of Excellence

Think again of education as a way or a bridge across a wide and deep valley, a means whereby something of value is reached leaving ignorance behind. Does this simile mean anything to you? Is the way clear and bright? Every bridge has structural members, each a part of the bridge itself and each necessary for its structural unity. As an example of the unity required, I wish to quote from President V. M. Hancher of the State University of Iowa in his charge to the candidates at commencement two weeks ago.

"Education has many tasks and many ends, one is that education in mid-Twentieth Century America should be the development of excellence among all our people."

"The development of excellence implies respect for the best. The development of democracy implies respect for the majority. How can education in mid-Twentieth Century America recognize two masters? Upon what principle or principles can we reconcile the superiority of excellence on the one hand with the consent of the majority on the other?"

"Now the tasks or functions of educational institutions are appropriate tasks in a democratic society attempting to establish economic independence and achieve social unity and cohesion. But, by stressing conformity, by substituting the judgment of the crowd for the judgment of the individual mind and conscience, they tend constantly toward mediocrity."

"Conformity is understandable, it is comfortable, it is easy. Usually it represents the average. There is nothing about it that stands out from the crowd. It possesses no sharp edges. It does not invite strange new thoughts, strange new

modes of conduct, or strange new patterns of life for the individual. It does not welcome eccentricity. It admires gregariousness, the current cliche, the predictable reaction."

"Democracy, based as it is on respect for human personality and dedicated to the preservation and sanctity of the individual, can easily degenerate into sentimental equalitarianism. This is equality run riot. Starting with the principle that all men are created free and equal in the sight of God and before the law, we end with the foolish notion that all men are identical in their gifts and powers. We begin with the dignity of the individual and we end with *the theory of the interchangeable man.* We end with the theory that men, resembling parts of an automobile or of a television set, are equally useful and competent in all the positions in society in which they may be placed, just as inanimate metallic bearings may be shifted from one machine to another without loss or efficiency or precision."

"But men are not machines and there is no such thing as the interchangeable man. In our more reflective moments we all recognize that the two most striking characteristics of human beings are the vast range of their similarities on the one hand and the vast range of their differences on the other."

"The fundamental problem of a democratic society is the reconcilation of respect for personality on the one hand with respect for excellence on the other, the reconcilation of the rule of the majority with tolerance for individual departures from the majority, the reconciliation of the will and the beliefs of the many with the excellence of the few. Democracy must be on guard against the prestige of the composite man—the apotheosis of the average—the man whose beliefs and ideas are a composite of all the beliefs and ideas that he has ever heard, without form or logic and without arrangement or consistency. For a hundred and seventy-five years, we have possessed so many blessings that we have scarcely needed to stress the importance of excellence. But now we stand in a new day. Those who oppose our way of life, and their satellite nations, outnumber us many times. On a man power basis, we face inevitable defeat in any armed conflict. Our hope lies not in numbers but in excellence. Therefore, the quality of excellence must be our first concern."

"It carries with it a fundamental honesty. When we have inculcated in the members of our society the goal of excellence, we shall have achieved an essential integrity which will make every man his own unkindest critic."

"These are the attributes of excellence —clarity of perception, persistence, self-reliance, ease and grace—the attributes of that excellence which we need so much in these difficult times. How are we to reconcile the attainment of excellence with respect for the average? Is there any ground upon which the two can meet? Must excellence be ever scornful of mediocrity? Must mediocrity always be suspicious of excellence? How can these two—the insights of the superior and the consent of the majority—be reconciled to provide us with a richer and better society?"

"The reconciliation seems to call for a twofold interpretation of democracy. On the one hand democracy must inculcate in every member of society that quality of excellence which requires him to work at the highest level of his capacity. On the other hand, democracy must inculcate respect for every member of society who, driven by the desire for excellence, works at the highest level of his capacity. In such a society every member would be useful and every member would be respected. Such a society would be truly democratic. Such a society is needed at this mid-Twentieth Century."

"It was truly said by Bernard of Chartres that 'we are dwarfs standing on the shoulders of giants.' We humans, alone in the animal world, possess history, a kind of cumulative memory, whereby we are able to build on the foundations

which others have laid before us. By this device we are able to have at our command all the inventions of ages past. Through this device we have universities and colleges, hospitals and schools, vast foundations and corporations, the principles of representative and of Federal government and the great concepts of Justice, Freedom, Liberty and Dignity of Man, which are basic to our civilization."

I have quoted at length from the address of Dr. Hancher because it fitted perfectly into what I had already written before he gave his charge to the candidates. Now to return to my own wording.

Intelligence and Character

Many have labored on the bridge and as a result many things have come to us because of the excellence of the past. They are our heritage. They come to us without cost and without price. Our forefathers paid for this inheritance. But this places us under a greater obligation —an obligation that we in turn will make excellence our goal, in order that the rich heritage of the past may be made even richer for the future. The only way in which we can pay our debt to those who preceded us is by making a better bridge for those who falter by the wayside.

If the foundation of our bridge of education is character what about the other parts of the structure which are equally necessary to carry the load of all who wish to cross from ignorance to understanding? I would first put intelligence as the main member, reliability is another and so we could go through the list of desirable attributes of the educated man such as tolerance and justice and knowledge of the world and of the individual, which must be contrasted with the treatment of man as a unit of the state and no value except as he conforms to the wishes of the state.

In conclusion, let me point out that the bridge permits going both forward and backward. We must be ever on the alert to see which way our students are likely to go. Mere mental exercise is not enough; just as a man walking back and forth on the bridge will not get him to the other side, so intellectual dilettantism will not produce results.

Our way, our method, our medium for progress requires a strong structure to stand the strains of the multitude who wish to cross, affected as they will be by the winds of adversity and the frosts of an inhospitable world; a bridge on a firm foundation, constructed with good materials, all welded together by science and technology, tempered with human kindness and love will enable us as teachers to be of value to our students. That is what is expected of us as men and women dedicated to a most challenging profession, namely that of being teachers of Engineering. Education is a way, a method of achieving certain desirable goals. May the whole structure show excellent craftmanship. May our Society be ever alive to its responsibilities.

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Lustre or Glitter?*

By JOHN A. HANNAH

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It is heartening to a college administrator to realize that such a Society as this exists and has a history of robust action. Engineers are generally considered to have extraordinary pride of profession. That they should have pride in the teaching of engineering sets them somewhat apart from some other groups I could name. They are distinctive, too, in that they are keenly interested in the commercial practice of their profession, and wide awake to all the governmental and social changes affecting engineers and engineering. You are to be congratulated upon your alertness and serious purpose; I sincerely hope you never lose your enthusiasm, for that enthusiasm is in a large measure responsible for the steady advancement American engineering has made in the comparatively brief period of its existence as a recognized profession, and for the high standards of engineering education in the United States.

It may not be news to many of you that Michigan State College was the forerunner of the land-grant colleges and universities of America with which so many of you are associated. Nearly a century ago there was established here on this campus the first college in the world in which agricultural subjects were taught for college credit. The old Michigan Agricultural College was the result of years of agitation on the part of those who were not content that higher education should be reserved for the sons of the rich and well-born, and who insisted that the promised benefits of scientific discoveries should be available for the solution of the troublesome problems of agriculture on the frontier.

Fore-runner of the Morrill Act

This pioneer college, having a revolutionary philosophy that the problems of living people were fit subjects for study by the best minds in a university, was established in 1855, ninety-six years ago. Within seven years, this revolutionary notion had made such headway that Congress passed the historic Morrill Act, creating the unique system of higher education known as the land-grant college system.

It is to the credit of those who were concerned with the industrial development of the United States that when President Lincoln signed the Morrill Act, it contained the mandatory provision that in addition to agriculture, the mechanic arts (what we now call engineering) should be taught in the new land-grand colleges, along with military tactics and subjects deemed desirable for the liberal and practical education of the industrial classes in the several pursuits and professions of life.

The passage of the Morrill Act creating the land-grant college system was one of the major contributions of America to the development of higher education. The freeing of higher education from its traditional bonds of the classical curricula, the reversal of educational interest from the dead past to things of the present and future, and the opening of the door of educational opportunity at the highest level to the sons

* Presented at the General Session of the ASEE at the 59th Annual Meeting, East Lansing, Michigan, June 27, 1951.

and daughters of all of the people instead of only the families of the rich or well-to-do are responsible to a great degree for the tremendous material progress this nation has made in the last 80 years.

I doubt that Senator Morrill, or even wise Abraham Lincoln, properly evaluated the creative forces they were unleashing. They were highly optimistic, of course, but it is to be doubted that even they could have understood how greatly they had wrought in placing the tools of creation and production in the hands of the common people, and training them in their use. They made possible the multiplication of native skills and aptitudes a thousand times, and made possible those miracles of agricultural and industrial production with which we amaze and dumbfound the rest of the world as a matter of routine.

Frankenstein Attributes of the Machine Age

Even in that era, many were impressed by the possibilities of the machine, and considered that they had come far along the road to the ultimate in discovery. For example, we find Emerson saying:

> "Armed with his machinery man can dive, can fly, can see atoms like a gnat; he can peer into Uranus with his telescope, or knock down cities with his fists of gunpowder."

How astounded he would be if he could see the machines man has since built to do his bidding—and possibly, to accomplish his own destruction.

But perhaps Emerson would not be too astonished, after all, for he said this, too: "Things are in the saddle and ride mankind." Perhaps he would not be surprised to find mankind cowering in fear before the threat of the greatest machines of all, the products of rare inventive genius and great productive skill, perverted to an unholy purpose—the mass suicide of mankind.

The metaphor of Frankenstein's monster has been overworked in discussions of the plight of mankind in the Age of the Machine, but it has validity in emphasizing that man is in danger of destruction beneath the wheels or in the disintegrating flash of his own creations.

The error in our thinking is in attributing to the Machine all the attributes of human beings or of God himself—the ability to choose between good and evil, to create, to destroy, to accomplish miracles. We have failed to understand that in and of themselves, machines are utterly without value. By themselves, they can accomplish absolutely nothing. They are still subject to the will of man, and reflect in their accomplishments only the good or evil purposes of the men who operate them.

A great many people in our country have failed to understand this important point, and as a result too many Americans have been and still are members of the Cult of the Machine, and worshipers at its altar. Planes in flight, television, radio communication, streamlined trains, electronic permanent wave contrivances, electric scoreboards, motion picture films in technicolor—all these things have excited our admiration, and in too many cases, our idolatry. Those wonderful, shining gadgets of ours were the envy of the world though the roaring twenties, even through the great depression of the thirties, and most of all in World War II. Machines can do anything, we said to ourselves, and tried to glamorize our idols by streamlining them and painting them in bright and beautiful colors.

The Machine has had to share a place with the dollar above the altar of the materialistic among us. The Machine, of course, is the top-ranking god, for the dollar is in a very real sense the product of the Machine. But we have placed much faith in the dollar to perform tasks for us—indeed, sometimes it seems that we believe that anything can be bought with money, even peace and the love and admiration of all mankind.

But in recent years, as international tensions have persisted after the war that was to be the last great war, and as we

go on building more magnificant machines to preserve a precarious margin of safety in a world seemingly bent on war, we Americans are beginning to wonder whether our faith in the Machine and in the Dollar has not been misplaced.

Are we on the Right Track?

We have achieved the world's highest standard of living; we have put together the world's most stupendous industrial system; we have only six per cent of the world's population, and only seven per cent of its area, but we account for roughly half of its industrial output. We have loaned and given away billions of dollars in cash and credit and foodstuffs and industrial machinery. We have given away still more billions in the form of machines of war.

We have done all this, partly out of native generosity and partly out of self-interest, and what do we have to show for it? We have earned the bitter enmity of a good share of the world, an uneasy alliance with a smaller portion, and a close alliance with a very small portion. But we have not bought, with all of our dollars and all of our machines, the peace and security which we Americans cherish as our greatest ambition.

It is no wonder that we are beginning to question whether we are on the right track and beginning to ask whether we dare place our faith in machines, and in dollars, alone. That gnawing wonder is to blame for a great deal of the insecurity that all Americans feel these days when we see our taxes mounting, the cost of living mounting, the piles of war supplies mounting, and no peak in sight for any of them.

It is axiomatic that he who claims the credit for a particular plan or process is liable for the blame if the plan fails or the process goes awry. The unthinking folk who loudly sang the praises of the scientists for making all our wonderful gadgets possible are quick to say the same scientists are to blame when they find that those gadgets are not all they had expected them to be. As engineers, you have had your share of the blame from those whose thinking runs like this: If the atom bomb had not been invented by men like you, we would not be in this trouble today; if you had not developed all these wonderful mechanical devices, we would not be working ourselves to death trying to keep up with this mechanical world.

The fallacy of such thinking is obvious: the inventors and scientists and manufacturers and engineers are no more to blame for the miseries of the world than they were entitled to all of the credit when everything was going well.

Neither are the machines themselves to blame—the atom bomb is of no more importance than a grain of sand without man to direct its flight to the target and to time its detonation. It makes no difference at all to a mass of fissionable material whether its latent power is to be used for the generation of industrial power or the destruction of an indutrial city. The decisions lie in man, the thinking animal, not in the inanimate machines to which we have falsely ascribed so many human attributes. To paraphrase the famous words of Shakespeare: "The fault is not in our machines, but in ourselves—all of us."

This national malady of insecurity, and its causes, have great importance for those engaged in educational pursuits, perhaps more than for any other group, for we have been largely responsible for the condition. We have had as our task the training of the leaders of this country: it is we who have encouraged them in a materialistic view of life; it is we who have countenanced the stripping from the scientific curricula of the cultural subjects, and graduated engineers, who, we were proud to say, knew engineering and little else, biologists who knew biology and little else, chemists who knew chemistry and little else. Is it any wonder that these poor deluded students have not known what to do with their technical knowledge?

Who is to blame if they have not been trained to estimate the likely conse-

quences of their actions, and to judge their actions from the standpoint of social responsibility? How many educators have cried out in protest against a system that rewarded industrial genius with great material gains, and paid a comparatively small pittance to the musical genius or the great philosopher?

Is There Hope?

If our national feeling of insecurity is indeed attributable to a slackening national faith in material things, then I see great hope for America. Perhaps the American people will come in time to respect and honor—and reward—those who produce thoughts and ideas as well as those who produce things. In these times, when we find that our material advantages have not brought us peace and security, perhaps we will come to agree with Emerson that "a rush of thoughts is the only conceivable prosperity that can come to us."

What I am advocating here for education is a revamping and revision of curricula in many fields of study to make room for some of the courses directed to training students' minds and to refreshing their inner spirits, so as to make of them whole men and women instead of technical instruments prepared to carry out their mechanical functions in making adequate livings, but failures at making lives for themselves and others with whom they come in contact.

George Boas, the eminent professor of philosophy at the Johns Hopkins University, pleaded a strong case for the humanities and the social sciences recently at a symposium on Higher Education and Long-Range National Security. He made the telling point that "when all is said and done, it is the philosophy and poetry and architecture and sculpture (of the cultures of the past) which have survived as dynamic forces."

He went on to decry the current attitude towards students in his own and related fields, and made this comment:

"We are in a national situation where millions are being spent daily on studies the results of which will be weapons. The more deadly the weapons the better. Pure science is tolerated because it is suspected that it may contain implications useful for warfare. Psychology and economics are tolerated because it is hoped that the former may teach us how to beguile the enemy successfully into treason or cowardice, the latter because it may teach us how to capture or destroy the materials vital to the enemy's defense. But the historian, the student of language and literature, and especially that human gadfly, the philosopher, are not encouraged. They are not essential to defense. They are merely essential to civilization."

With due allowance for his natural prejudice, I believe we can agree that he has pointed to a fundamental weakness in our national character—our preoccupation with facts and figures to the exclusion of the human factors that play the major roles in determining human conduct and human history.

Glitter and Intrinsic Value

I do not mean to advocate the liberal arts curriculum for everyone, or for education obtained by reading 100 great books. One must be alive to enjoy life, and most of us have to earn a living to stay alive.

But on the other hand, students coming under our guidance and control must be taught some things beyond mere technical competence in their professions. Specifically, it is not enough to teach engineering students engineering and related subjects and little else. They should not leave our colleges and universities with the mistaken notion that everything in life can be reduced to a mathematical formula, and their relations with their fellow men determined by slide-rule calculations.

It does not matter how the broadening of study courses is accomplished. Here at Michigan State College, we maintain our Basic College, in which all of our freshmen and sophomores are required to take a number of common core courses

in which they are introduced to materials in all the great fields of knowledge. The purpose is to guarantee that we will no longer graduate music majors who know nothing of the physical and biological sciences, engineers who know little or nothing of history or art or the biological world in which they live, chemists who know nothing of the sciences in bordering fields or of the social sciences. And they all are required to demonstrate a reasonable proficiency in written and spoken English before they can earn a degree from this College.

But while we are broadening our courses to produce graduates who can honestly claim to be educated, we must narrow them too, in order that they may focus on some of the fundamental truths of which we have lost clear sight in recent generations. The glitter of modern civilization has obscured too much of the intrinsic value of such old-fashioned things as respect for the rights of others, respect for the persons of others, respect for the property of others, and respect for the opinions of others. Teachers of whatever subjects would be serving well if they laid some stress on those fundamental principles of conduct for the benefit of their students.

But most of all, I am sure you will agree, we must teach students to *think*. And they must learn to think, not only about problems in their own spheres of activity but about a great many other things as well. It seems evident that we cannot leave great decisions on matters of national and world policy to a small group elected or appointed to perform those specific functions. I believe that the decisions of the great mass of Americans will potentially be much sounder than those of any politicians ever elected to any offices. But they cannot be sound decisions unless they are based on comprehensive information and rational thinking. Colleges and Universities fail in their greatest mission if they are not truly centers for the encouragement and stimulation of thinking on the part of students and the general public as well.

Those who question whether the designer, the builder, and the operators of our machines should assume any social responsibility for the results of their actions might look with profit at the example set by such distinguished scientists as Compton, Einstein, DuBridge, and Bronk.

These men, who know better than any others the awful potentialities of atomic power, fully recognize the probable consequences of their creative action, and are laboring mightily to develop a social-political climate favorable to effective control of atomic energy for the benefit of mankind. Their concern does them great credit; their endeavor to minimize the destructive effects of their discoveries is a tremendously hopeful development. And if men such as these are prepared to assume some responsibility for their actions, then it is highly appropriate that others do likewise.

The Balance Between Specialization and Liberalization

Interested as we are in the present and the future, there is always something to be learned from the pioneers of the past. It is humbling to find that those who laid the foundations for our great industrial and economic development here in the United States saw far more clearly than we of recent generations the dangers of undiluted science and narrow specialization in education.

It is particularly appropriate here on this campus to recall the words of Bela Hubbard, one of the Michigan farmers who helped bring into being this first agricultural college, the forerunner of the land-grant college system. On one occasion, Hubbard described what he considered to be the ideal curriculum for the college he had in mind, and the emphasis was placed on the natural and physical sciences. But then he added a note of warning in which we now recognize wisdom and far-seeing vision. This is what he said:

"Nor should the claims of literature and the fine arts be wholly neglected, as tending to polish the mind and manner, and add greater lustre and dignity to life."

Remember, he was talking about education for the sons of farmers and workers here on what was then the frontier—and he was advocating that they study literature and fine arts. He was mightily interested in their receiving the scientific training they required to cope with the technical difficulties of farming, but he wanted their lives to have lustre and dignity, too. He might have been speaking as well for the engineers, the veterinarians, the home economists, the business administrators, and all the others who were to be trained here in the century to come. He might have been speaking for all the young men and women to be trained for the "several pursuits and professions of life," as the Morrill Act stated it. Incidentally, it is well to note that the Morrill Act provided for the "liberal and practical education" of the industrial classes of America, not the practical alone.

There is ample historical precedent for the idea that a college student shall have training narrow enough to equip him to make a living, and broad enough to equip him to make a life.

The young men and women we are sending into the world with diplomas in their hands will encounter some of the most perplexing questions ever to vex a generation. We will be doing less than justice to them if we do not give them the background of knowledge and the thinking knowhow they will require in the years ahead.

Determining just what that background and training should be is of course a task for individual teachers and individual colleges. But as a guide, we might remember that Milton more than three hundred years ago, in one of the best definitions of an education ever written, defined an educated man as one who can perform all the offices of peace and war with justice and magnanimity.

In the final analysis, an educated man in a democracy is one who is trained and conditioned to be an effective citizen. He need not necessarily be a man who has attained great wealth, or professional distinction, or high public office. He may not be known far beyond the borders of his own community.

But he will have been educated to contribute to the economic stability to the limits of his creative and productive skills; he will have been educated to contribute to the social stability by his understanding of the world around him and his tolerance for the rights and opinions of others; he will have been educated to contribute to the moral stability by his acceptance and observance of the fundamental values; and he will have been educated to contribute to the political stability by his reasoned, thinking approach to political issues, his rejection of demagogic appeals, and his willingness and ability to lead or to follow, with equal intelligence.

If we will keep such definitions of education in mind, we as educators will not think so much of graduating engineers, or chemists, or teachers, or home economists, or agriculturists, or accountants, as of graduating educated men and women, trained to be effective citizens of our democracy—men and women ready and willing to assume the duties of leadership in a nation crying for intelligent direction and guidance in a world full of confusion, insecurity, and doubt.

By so doing, we will contribute to the preservation and further advancement of the nation we all love, for men and women so trained will have confidence in America, her principles and her destiny, and confidence in America's ability to lead the world into an era of peace and understanding.

Lamme Award—1951—Allan R. Cullimore

To ALLAN REGINALD CULLIMORE, *engineer, soldier, teacher and engineering administrator, for his achievements as an engineer-citizen; his constructive statesmanship in engineering education; his devotion to the cause of young people in the Boy Scouts movement; and advocacy of citizenship training in engineering education; his consecration to the cause of young engineers as evidenced by his work in Engineers' Council for Professional Development, and his contributions to engineering practice as a member of this and other engineering societies, we award this the twenty-fourth Lamme Medal.*

ALLAN REGINALD CULLIMORE was born in Jacksonville, Illinois, on March 2, 1884, the older son of Dr. Thomas McIntyre Cullimore, a local physician and surgeon, and Mary Joy Cullimore—both parents being direct descendants of residents of Massachusetts Bay Colony. He attended the public schools of Jacksonville, where much of his boyhood was spent, and in 1903 enrolled in the Massachusetts Institute of Technology, after an early experience as Assistant in the United States Coast and Geodetic Survey along the Columbia River in Oregon had led him into the field of engineering.

In 1907 he graduated from M.I.T. with the degree of B.S. in C.E., and joined the instructing staff of the Institute as an Assistant in the Department of Civil Engineering. In 1909 he accepted a position as Superintendent of Construction in the City of St. Louis, and later was promoted to responsible charge of construction work on the erection of the new court house.

Dr. Cullimore's work in the field of engineering education began in 1912, as Dean of the College of Industrial Science of the University of Toledo. He founded that College, organizing and planning its courses, and for a time occupied the position of Acting President of the University

In 1916 Delaware College (now the University of Delaware) appointed him Dean of Engineering. His services at Delaware, however, were interrupted by the entrance of the United States into World War I. At the outset of the War, Dr. Cullimore was in charge of special courses for shipbuilders in the shipyards of Wilmington, Delaware, as well as specialized training for the U. S. Signal Corps in Wilmington. During this period he gave considerable time to the study of industrial accidents, particularly with the object of rehabilitation of workers crippled in industry. He made an extended tour through the United States and Canada, visiting hospitals and studying the work being done in the rehabilitation of wounded soldiers. On his return to Washington he was assigned by the Surgeon General of the U. S. Army to organize the program of rehabilitation on the Pacific Coast. Shortly afterward, he was commissioned a Major in the U. S. Army in Charge of the Division of Physical Reconstruction attached to the Office of the Surgeon General.

After the War he resumed his duties at Delaware College, also serving as General Consultant for the Federal Board for Vocational Education, which later became the Veterans Bureau.

In 1919 Dr. Cullimore left Delaware to undertake the development of engineering education in Newark, N. J. It has been at Newark, first as Director of Newark Technical School and Dean of the newly founded College of Engineering, and from 1927 to 1949 as President of the Newark College of Engineering, that Dr. Cullimore has pioneered, developed, and expanded the field of human relations in engineering education. It was through his efforts that the study of the humanities was introduced on an equal level with technical studies. He felt that only through this sense of social awareness could the successful engineer understand and work harmoniously with his fellow men.

Significant contributions which Dr. Cullimore has made have resulted from his firm conviction that those qualified young men and women who lacked financial means should have opportunities to obtain a sound engineering education. As a result of his unceasing efforts on their behalf, any high school graduate in the State of New Jersey who has the aptitude for and the interest in engineering need no longer be denied an engineering education because of lack of funds.

Synonymous with his efforts to equalize opportunity as well as to broaden the scope of engineering education, is Dr. Cullimore's interest in the proper guidance of youth. He served as Chairman of the Committee on Student Selection and Guidance of the E.C.P.D., and upon completion of this assignment, undertook the Chairmanship of the Subcommittee on Student Development of the Committee

on Engineering Schools, resulting in the publication of "The Most Desirable Personal Characteristics."

At the outbreak of World War II Dr. Cullimore was appointed Regional Adviser in Region No. 5 of the E.S.M.W.T. Program sponsored by the U. S. Office of Education. Concurrently with his work in the War Training Program, Dr. Cullimore served the N. J. Office of Civilian Defense as a member of the Technical Advisory Committee and as Director of the Newark Area, and was Regional Representative for the War Manpower Commission.

One of the principles which Dr. Cullimore has emphasized during his career at Newark is the engineer's responsibility as a citizen. In 1933 he was appointed Chairman of the Committee on the Engineer's Civic Responsibility of the A.S.M.E. In collaboration with the late Senator Roy V. Wright, he was responsible for the dissemination of this idea to students and young engineers, in the formation of a permanent lecture series at Newark College of Engineering.

Dr. Cullimore has been recognized as a leader in civic affairs in the Metropolitan Area of Northern New Jersey for thirty years. He has been active on numerous committees of the Chamber of Commerce of the City of Newark and of the State of New Jersey; has served on the Citizens' Advisory Committee to the Central Planning Board of Newark, and the Advisory Council of the Newark War Veterans' Service Bureau; and has been Chairman of the Essex County Council of the N. J. State Division Against Discrimination.

With his background in rehabilitation work, Dr. Cullimore serves as a Trustee of the Kessler Institute for Rehabilitation, one of the leading pioneer sanitoriums in this field. He has also acted as an advisory committeeman for the U. S. Department of Labor in its Study of the Utilization of Impaired Workers in Industry.

Over a period of years Dr. Cullimore has been active in the A.S.E.E. He was First Vice President in 1943–44; member of the Council 1940–43; has been Chairman of The Committee on the Orientation of Freshmen, Committee on Undergraduate Adjustment and Guidance, Committee on V-12 Examinations, and Committee on Conferences; and has served as a member of numerous other committees.

In line with his general enthusiasm for the welfare of young men and boys, Dr. Cullimore has shown a deep interest in the Boy Scouts of America. He was the recipient of the Silver Beaver Award for 1937 and the Silver Antelope Award for 1947, both for distinguished service to boyhood.

Dr. Cullimore holds the honorary degrees of D.Sc., University of Newark; D.Eng., Newark College of Engineering; D.End., Stevens Institute of Technology; and D.Eng., Rutgers University. He is First Honorary Member of the Professional Engineers' Society of Hudson County, New Jersey; member of Tau Beta Pi, Beta Theta Pi, Phi Kappa Phi, and Omicron Delta Kappa; member of the Newcomen Society, the Engineers' Club of New York, the Down Town Club of Newark, and Honorary Member of Newark Rotary.

He is the author of several publications, including: "Theory of the Slide Rule," 1913; "The Phillips & Mannheim Rule," 1923; "Selections for Engineering Students," 1929; "The Problem of Staff," 1933; "Anent Engineering and Culture," 1932; "Through Engineering Eyes," 1941. He has also contributed numerous articles to technical publications.

Since his retirement as President of Newark College of Engineering, Dr. Cullimore has been devoting a considerable part of his time to a project that had long been in his mind—the correlation of Industrial Relations and Personnel Relations work into an expanded Department of Management and Personnel at Newark College of Engineering, which he guides as Chairman.

In 1912 he married Edith Van Alst of Brooklyn. Their home is in South Orange, New Jersey.

George Westinghouse Award—1951—
Glenn Murphy

To GLENN MURPHY, *a master craftsman of the teaching art. Unsparing of himself, he develops in his students at each level of age and background the desire and ability to think; an eagerness to learn; a willingness to work. An exacting task master, a proflific writer, a skillful improvisor, an able supervisor of junior colleagues, he advances teaching along the broad front of precept, example and a genuine personal interest in each student with whom he has contact.*

GLENN MURPHY, sixth recipient of the ASEE George Westinghouse Award, has demonstrated an almost unbelievable versatility in his teaching and related accomplishments. While his proven productivity and growth potential are truly outstanding, even more remarkable is the forward pace which continues without sign of letup. One has but to scan thoughtfully the titles of Dr. Murphy's writings to recognize the technical versatility of the man at both graduate and undergraduate levels.

Of him one colleague has written: "In summary my appraisal of Dr. Murphy is that he is a master of teaching; he can successfully lead the student into the pleasures of real learning. He is a master of his subject matter; his publications bear witness to this fact. He has never been content to rest on past accomplishments." In the words of a former student: "Dr. Murphy enriches his students by far more than the technical information which he so capably presents. It is in his development of logical minds with the ability and fortitude to tackle new problems which cannot be dealt with by formula, that he makes a truly great contribution to the engineering profession."

Born in Boulder, Colorado, January 17, 1908, Murphy took his B.S. in civil engineering at the University of Colorado (with special honors) in 1929, followed by the M.S., 1930 and the professional CE, 1937. After a two-year assistantship at Illinois in the midst of the stimulus created by such mentors as

Wilson, Huntington, Moore, Seely, Richart, Westergaard and Cross, Murphy, in 1932 with his second M.S. degree became the fifth member of the year-old T. & A. M. staff at Iowa State College. Continued study concurrent with his teaching netted in 1935 the Ph.D. At the age of 33 he became, in 1941, a professor. With his marriage in 1934 to Frances Pearce, he secured a brilliant cooperative helpmate whose name receives well-earned mention in the preface of virtually every one of his books.

In spite of the heavy output and wide range of subject matter, the textbooks carry, not only the stamp of quality and educational craftsmanship but at least two of them document areas heretofore without comparable textbook coverage. Titles include: Properties of Engineering Materials, Materials Testing (co-author), Mechanics of Fluids, Mechanics of Materials, Advanced Mechanics of Materials, and Similitude in Engineering. He was also co-author for one section of the O'Rourke "General Engineering Handbook." In addition to the books is authorship or co-authorship of three Iowa Engineering Experiment Station research bulletins and various papers and discussions published under such auspices as ASTM, ASEE, ASME and the Seventh International Congress for Applied Mechanics. A major editorial task is his position as Editor, Mechanics Series for Ronald Press. He has also long been an abstractor for the *Journal of the American Concrete Institute* and currently abstracts for the *Applied Mechanics Review*.

As Senior Engineer in the Institute for Atomic Research (half time) since 1949, Dr. Murphy is in charge of the Nuclear Engineering group in the Ames Laboratory of the Atomic Energy Commission. He is a registered professional engineer in the state of Iowa.

Of professional affiliations the list is long but representative of actual interests and in most cases participation. A member of ASEE since graduation in 1929, Dr. Murphy is a former member of the Council, a past chairman of the Mechanics Division and at present Editor of the *Bulletin of the Mechanics Division*, launched in 1950 during his chairmanship. The 1950 ASEE Summer School for Teachers of Engineering Mechanics (the first since 1929) was his conception and with the aid of loyal colleagues it proved to be a highly successful undertaking and the largest mechanics summer school yet held.

Other technical affiliations include ASCE, ASME, Amer. Conc. Inst., Soc. Exper. Stress Analysis, Iowa Engr'g Soc., Inst. of Aeronautical Sciences and Inst. Argentina de Racionalización de Materiales in addition to the honor societies of Tau Beta Pi, Chi Epsilon, Phi Kappa Phi and Sigma Xi (President of the local chapter 1949–50).

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

The Nature of Good Teaching*

By R. L. SWEIGERT

Dean of Graduate Division, Georgia Institute of Technology

The improvement of teaching at the college level involves many things. Some of these are concerned with what goes on in the classroom and some are concerned with matters that indirectly affect what goes on in the classroom.

Trained teachers are needed now for most all fields of human action. In former years the college degree in some miraculous manner was supposed to qualify one for teaching. However, it is now evident that knowledge of subject matter alone does not provide complete qualifications.

The following items are a condensation from an article on the improvement of college teaching by Dr. C. C. Crawford of the University of Southern California. They indicate that there are many components to the job of good teaching and are listed for that reason.

1. The starting of a career in college teaching.
2. How to win and hold the good-will of students.
3. How to operate classroom routine.
4. How to keep student interest at a high level.
5. How to make your teaching practical, functional, or worthwhile.
6. How to plan and organize college courses.
7. How to prepare functional syllabuses and textbooks for college courses.
8. How to manage related library and textbook materials.
9. How to direct the exchange of ideas.
10. How to persuade, convince or influence college students.
11. How to speak effectively in the college classroom.
12. How to illustrate or demonstrate your ideas.
13. How to direct student practice or performance.
14. How to promote originality, research and invention.
15. How to improve the learning techniques of college students.
16. How to fit instruction to varied abilities and needs.
17. How to maintain proper levels of work and mastery.
18. How to teach many students at one time and manage large classes.
19. How to check up on student accomplishment.
20. How to help young people to plan and manage their lives.

Since this discussion is on the nature of good teaching the items mentioned above will not be expanded upon.

All higher education will be benefited when some group has the imagination and courage through comprehensive research and study to formulate criteria of good teaching, systematic procedures for appraising it, and the most effective steps for its improvement.

In any discussion of improving college teaching or of training college teachers it seems necessary that there be

* Presented at the Southeastern Section Meeting of the ASEE, Biloxi, Mississippi, March 22–24, 1951.

some statements made as to what constitutes good teaching; what is the nature of good teaching. Effective learning is the result that the good teacher is after, because, after all, if there is no learning there is no teaching. One definition of learning that seems very appropriate is: "Learning is a *change in performance* as a function of practice, the change having a direction that satisfies *current motivation* of the individual."

The change in performance that we are concerned with is the production of increased competence in the field being studied. This involves (a) producing an understanding of the fundamentals; (b) developing the ability to use the fundamentals in new situations. These become prime objectives in the educational process.

Learning and Motivation

To accomplish the two objectives, the manner in which we learn must be considered. Some basic concepts can be taken from educational psychology.

1. We learn by doing (mental or physical). The question can be raised: Does anyone really learn by passive acceptance? The answer of the psychologist seems to be largely in the negative.

I would like to give the following quotation: "There's one and only one way to receive an education, that is to get it for yourself. We hear much said about self-educated men, and a broad distinction is made between them and others; but the truth is, that every man who is educated at all, is, and must be, self-educated. There are no more two methods in which the mind can make progress than there are two methods in which plants can grow. One seed may be blown by the winds, and cast upon the southern, or perchance on the northern side of some distant hill, and there germinate and take root, and do battle along with the elements, and it may be so favored by the soil and climate that it shall lift itself in surpassing strength and beauty; another may be planted carefully in good soil, and the hand of tillage may be applied to it, yet must this also draw for itself nutriment from the soil, and for itself withstand the rush of the tempest, and lift its head only as it strikes its roots deep in the earth. *It is for the want of understanding this properly that extravagant expectations are entertained of instructors, and of institutions; and that those who go to college sometimes expect, and the community expect, that they will be learned of course, as if they could be inoculated with knowledge, or obtain it by absorption.* This broad distinction between self-educated man and others has done harm; for young men will not set themselves efficiently at work until they feel that there is an all important part which they must perform for themselves, and which no one can do for them." The above is from Mark Hopkins, 1836. It apears to me that this statement is as good today as the day that it was made. It is unfortunate that we have not given greater attention to such key concepts stated many years ago.

2. Consideration should be given to stimulus-response reactions. The time necessary for learning, the effect of plateaus of learning, and the matter of forgetting (the reverse of learning) all enter the educational process.

3. There must be consideration of the motivation limit, the matter of incentives. (A student goes no further than he desires.)

4. We need to give adequate and full consideration to how learning takes place.

a. First we have motivation; the matter of rewards, punishment, competition, and satisfaction must receive attention.
b. Next we are concerned with the conditioning of the student or with preparing him in such a way that he is in a state of readiness for learning, that his attitude is the best for learning.
c. Then a task must be established. This means having definite objec-

tives and definite work to be done by the student.

d. We learn by doing, by practice. Therefore the problem of student action and repetition comes to the fore. Repetition means the use of time, and time is limited. Therefore we need to know at least roughly, the extent of repetition necessary to provide the necessary improvement in performance.

e. We receive through the various senses. Therefore we need to know how to use these various senses in the most effective way to get the results we are after. All things mentioned about the student involves student activities. It needs to be continually emphasized that all learning takes place through activity by the student.

We might list seven types of learning that would bear consideration in a first-class learning situation. While all seven are important, two of them involving the development of emotional activities and the development of attitudes and ideals will be passed over and five of direct relationship to learning in the sciences and engineering will be listed. These are:

1. The development of motor skills. (In the main this type of development would be minor in professional education except for experimentation.)
2. The development of perception—awareness of action.
3. Memorizing—association.
4. Development of understanding.
   a. Observation.
   b. Listening.
   c. Reading.
   d. Abstraction.
   e. Analyzing.
   f. Generalizing.
5. The development of problem solving.

Handicaps to Learning

There are certain handicaps to learning which bear careful attention, and which in many cases are given little consideration. These handicaps include:

1. Fatigue (both mental and physical).

   Factors affecting fatigue are:

   a. Number of classes in a row.
   b. Poor lighting.
   c. Poor desks.
   d. Poor tools.
   e. The pace too fast or monotonous.
   f. Poor teaching itself!

2. Distractions:
   a. Noise.
   b. Instructor mannerisms.
   c. Improperly used visual aids.
3. Poor ventilation.
4. Poor vision.
5. Poor acoustics.

Statistical studies made on the educational processes at three different institutions of higher education appear to give us some valuable information in regard to teaching from the viewpoint of the learner. Two of the studies involve undergraduates, one being made in a non-research type of institution, and the second being made in an institution that places considerable emphasis upon research. The study at the third institution was a study of graduates who had been out ten or more years. It was interesting to note that in the non-research institution the Associate Professors ranked at the bottom and in the research institution they ranked at the top of the list in the quality of their teaching. In the non-research institution, young instructors, the group with the least experience in teaching, ranked above both Assistant and Associate Professors. According to the students they possessed one characteristic at a much higher level than the older men, and that was enthusiasm. The faculty was rated lowest on its ability to stimulate students, while students gave a

very high rating to this characteristic as an element of good teaching.

Four Basis Elements

From the above basic concepts on learning and from the statistical studies made there have been determined what may be called four elements of good teaching. These four most important elements of good teaching stated in the order of importance as determined from statistical studies made with students and successful alumni are:

1. *Inspiration* (motivation). Every word and every action of the teacher encourages or discourages, creates a desire to learn or destroy the incentive to learn.

2. *Ability to explain*—coupled with patience, sympathy, and willingness to explain, it is a top asset.

3. *Knowledge of field.* An instructor's knowledge should be such that he does not have to concentrate upon the material but can concentrate upon the student.

4. *Organization.* Clear and concise statements of over-all and individual class objectives are essential. Various assignments should dovetail.

If an instructor knows his field, properly organizes his work, can and is ready to explain, and above all, can stimulate and motivate his students to a high level of activity, he is bound to get excellent results as demonstrated by the very nature of learning itself. Improved performance through developing understanding and ability to use fundamentals in new situations will result.

College Notes

A plan for a liberal education in engineering was announced by Dr. John R. Dunning, dean of the School of Engineering of **Columbia University.** Twelve selected liberal arts colleges have entered into an agreement with Columbia's School of Engineering to provide this unuusal opportunity for educating professionally trained engineers. A student interested in the study of engineering will have the opportunity of studying three years at one of the cooperating liberal arts colleges and two years at Columbia. Upon the satisfactory completion of three years of study at one of the twelve liberal arts colleges, the student will be automatically admitted to Columbia's School of Engineering for two years of engineering study. Completion of the five year program will result in appropriate Bachelor's degrees from both Columbia and the liberal arts colleges.

The College and Schools of Engineering and Mines at the **University of Pittsburgh** have announced a new cooperative program enabling students to gain training in both liberal arts and engineering. The plan includes a total of five years work and leads to a bachelor of science degree and a bachelor of science degree in engineering. Students entering this course and completing three years of work in the College and two years of work in the School of Engineering or Mines may satisfy the requirements for the bachelor of science degree from The College at the end of the fourth year and a bachelor of science degree from the School of Engineering or of Mines at the end of the fifth year. This program, which a student may enter next Fall, will be similar to two degree programs in effect for students in other liberal arts colleges.

Graduate Study in Structural Engineering*

By A. A. BRIELMAIER

Professor of Civil Engineering, Washington University

Need for Graduate Study

At the present time when so much is heard about training the engineer in the humanities and developing his social consciousness, it is with some hesitation that one brings forward the question of specialized training in one of the many fields of engineering. The present complexity, however, of all fields of engineering and the rate at which they are being explored and expanded make obvious the need for highly trained engineers.

It is the purpose of this paper to discuss briefly the general pattern of graduate study, to present an outline for such study in structural engineering, to consider the conditions essential to good graduate work and to formulate the aims of graduate study in structural engineering. The paper deals with graduate study in the United States of today which leads to the Master of Science degree after one year of study beyond the Bachelor of Science degree, and to the doctorate, either Ph.D. or D.Sc., after three years of study beyond the B.Sc. The advisability or feasibility of requiring some studies in the liberal arts at a junior college or at the university prior to beginning engineering studies, will not be here considered. Neither will the advantages or disadvantages of the five-year engineering curriculum be taken up; although adopted by several universities it is still the exception.

The engineering graduate is expected to have some acquaintanceship with the liberal arts in addition to broad engineering knowledge and special competency in one of the major fields. Of course it is impossible to achieve this in four years. The young engineer, leaving the university with the degree of B.Sc., has a general knowledge of the world he lives in, a fair ability to use written and spoken English, some knowledge of the fundamentals of all engineering and some familiarity with the subdivisions of his field of engineering. These subdivisions have however themselves become complex and the young graduate often finds it difficult to function satisfactorily in them without more knowledge than he obtained in four years at engineering school. This additional knowledge is frequently gained through experience. In some subdivisions of civil engineering it is very difficult to become competent through experience alone, even though it be supplemented by private study, superimposed on four years of formal engineering education. Structural engineering is one of these subdivisions.

The young civil engineering graduate of more than average ability who is interested in making structural engineering his life-work, whether in design or research, should seriously consider taking graduate work, at least to the extent represented by the M.Sc. degree. If he does not have this special training he may find himself inadequate for the performance expected of him and he certainly will find competition difficult with men of equal or perhaps less native

* Presented before the Civil Engineering, Division at the 59th Annual Meeting of the ASEE, East Lansing, Michigan, June 25, 1951.

ability who have had the training. In order, however, that he may know more surely where his interests lie and also that his studies may be carried out with the advantage given by greater judgment and some practical knowledge, it is desirable that several years of experience be obtained before advanced studies are started. In choosing the school for his future studies, it would be well for him to consider institutions other than the one where he received the B.Sc. in order to have contact with new teachers and new viewpoints.

Program of Studies

The purpose of graduate work in structures is to impart a specialized knowledge to engineers who already have an understanding of engineering fundamentals and a familiarity with the various sub-divisions of civil engineering. The detailed aims of the graduate program may be considered from two aspects: the knowledge to be gained and the mental attitude to be developed.

The knowledge to be gained may be roughly itemized as follows:

a) *mechanics:* usual assumptions, their validity and limitations; problems outside these limitations; elasticity and elastic stability.
b) *behavior of materials* (including soils) and structures: critical study based on experimental data.
c) *structural analysis:* frames consisting of members subjected to axial, flexural or torsional loading or to combination of these loadings.
d) *structural design:* members and framing of more than ordinary difficulty.
e) *thesis:* an independent but somewhat guided treatment of a problem in structural engineering or in mechanics, preferably one whose nature or solution is of timely interest.

The thesis for the M.Sc. degree is considered of great importance. Although it is impossible to delineate exactly the characteristics of an acceptable thesis, some general requirements may be mentioned. It is not expected that the thesis will be of such startling nature as to create excitement in engineering circles, but it is expected that the work would be of interest to many structural engineers. The application of well-known methods of analysis and design to a routine problem is not sufficient. The subject must be one of some difficulty, requiring a knowledge of the fundamental theory involved and calling for some originality in the solution. It must also be one whose treatment is not already well known and available. It is desirable that it be a problem of interest in the field in which it occurs. The effect desired on mental attitude is the promotion of independent thought, self-reliance and the courage to attack now problems. The thesis may have its greatest value when viewed in this light.

The subject matter just described might be presented in the following courses, each of which bears three credits, on the basis of twelve credits representing a semester's work and twenty-four credits being the minimum requirement for the M.Sc. degree:

Advanced Strength of Materials or Theory of Elasticity
Elastic Stability
Steel Design
Concrete Design
Soil Mechanics
Structural Analysis: Continuous Frames
Structural Analysis: Indeterminate Trusses
Thesis

The graduate program for the M.Sc. degree, based on the foregoing outline with perhaps one or two courses not directly related to the topics itemized, would require two very crowded semesters. Three semesters would be preferable since they would permit a slower pace with more time for reading and in-

dependent thought. The graduate program should never become merely a non-integrated collection of miscellaneous courses, whose chief purpose, although perhaps not recognized, is to keep the student occupied while he spends another year at school.

The two further years required for the doctorate may well be considered as an extension of the study for the M.Sc. degree, but with less rigidly prescribed course requirements. It is desirable that the M.Sc. degree be obtained in view of the experience gained in preparation of the thesis. The second year should be devoted to independent study of special topics in structural engineering and in mechanics, and to some formal courses, especially in mathematics. The nature of the courses would depend upon the direction of the student's interest. Along with these special topics and formal courses should go a developing familiarity with, and interest in, the literature and history of the fields of structural engineering and mechanics. After the second year is terminated with the comprehensive written and oral examinations, the third year is given entirely to the thesis which should deal with a major problem requiring theoretical knowledge and some originality.

Student, Instructor, Library

There are several features of graduate work, not yet mentioned, which are of primary importance to its success: type of student, type of instructor, library and laboratory facilities. Graduate study is not for the average student no matter how industrious, nor for the lazy student even though gifted, since both have a detrimental effect on the able and serious student and on the quality of instruction. Graduate classes should not be conducted by men who have just passed the course the preceding year or by those to whom instruction is an article-by-article trip through a textbook. The instructor, in addition to a broad knowledge of the subject, should also have an interest in it. The students come for advanced study mainly because they are interested. If the instructor cannot stimulate and increase this interest or enthusiasm, something is wrong. One instructor, even though of outstanding competence, should not furnish all the teaching in a graduate program. The complexity of the various subjects, as well as the advantage of having the students exposed to several viewpoints, would call for at least three instructors. Personal and friendly contacts between student and instructor are of the greatest importance. A student who is not free to obtain advice or who does not feel himself in a friendly atmosphere cannot do his best work.

Graduate instruction requires an adequate library; a collection of standard handbooks and texts does not serve the purpose. There must be available the usual reference works, proceedings of native and foreign societies, native and foreign periodicals, research bulletins and the like. Without these the graduate program is only a make-shift. Adequate facilities should also be available for experimental work, both for small-scale models and for larger specimens. It is desirable that these laboratory facilities be separate from those regularly used for undergraduate courses.

Summary

Summarizing briefly, graduate studies in structural engineering, competently conducted along a carefully thought-out plan, with the necessary library and laboratory facilities, should impart to the student a broad knowledge of theory and of the behavior of materials and the ability to apply this knowledge to actual problems of difficult and unusual nature. It should also develop or stimulate the habit of independent thinking and of initiative.

An Elementary Photoelasticity Experiment

By R. T. LIDDICOAT

Associate Professor of Engineering Mechanics, University of Michigan

For several years in the first course in materials testing at the University of Michigan, a photoelastic test has been included to let students know that such a method has valuable application to experimental stress analysis.

Bakelite was first used as a specimen material because it is so sensitive optically. It has about 20 times the sensitivity of glass and about 5 times the sensitivity of celluloid. After a few tests, or after a short time interval, the specimens developed considerable residual strains and the conclusions drawn from the test were not too reliable.

As a possible means of eliminating the residual strain objection it was suggested that glass be used as specimen material, and to make up for lack of sensitivity by employing the "Babinet Compensator." Small retardations of light can be accurately measured by this method.

The employment of the Babinet Compensator in tests performed by undergraduate classes seemed to be unusual enough to justify a presentation of its description.

Specimens of the desired shape were accurately cut from plate glass. In preliminary study the specimens were found to be free of residual strain. One specimen consisted of a plain bar, Fig. 1, about a quarter inch square in cross section and about 5 inches long. The other specimen, Fig. 2, was also of rectangular section, with a single half circular notch.

In the experiments the students were given the optical constant for the material. On the plain bar they then obtained the stress at the extreme fibres due to known bending moment by computation and by optical or photoelastic methods. Good agreement between these values gave confidence in the testing method.

FIG. 1.

FIG. 2.

The second specimen with the notch was then loaded, and the stress obtained at the base of the notch by optical means. The nominal or computed stress for a beam of uniform section but of the same reduced net cross section was then obtained. The actual or optical stress divided by the nominal stress gave the factor of stress concentration, which was a main purpose of the test.

The Preliminary Theory

There was some review of the fact that light is transmitted by transverse waves, that it can be polarized, that a polarized beam of light passing through a plane-stressed transparent isotropic body is repolarized at each point on the body into two planes parallel to the principal stress planes. As these two polarized beams emerge they maintain the initial frequency but they are thrown out of phase by passage through the material.

The phase difference or relative retardation of the two emerging beams is proportional to the difference of principal stresses at the point. The emerging

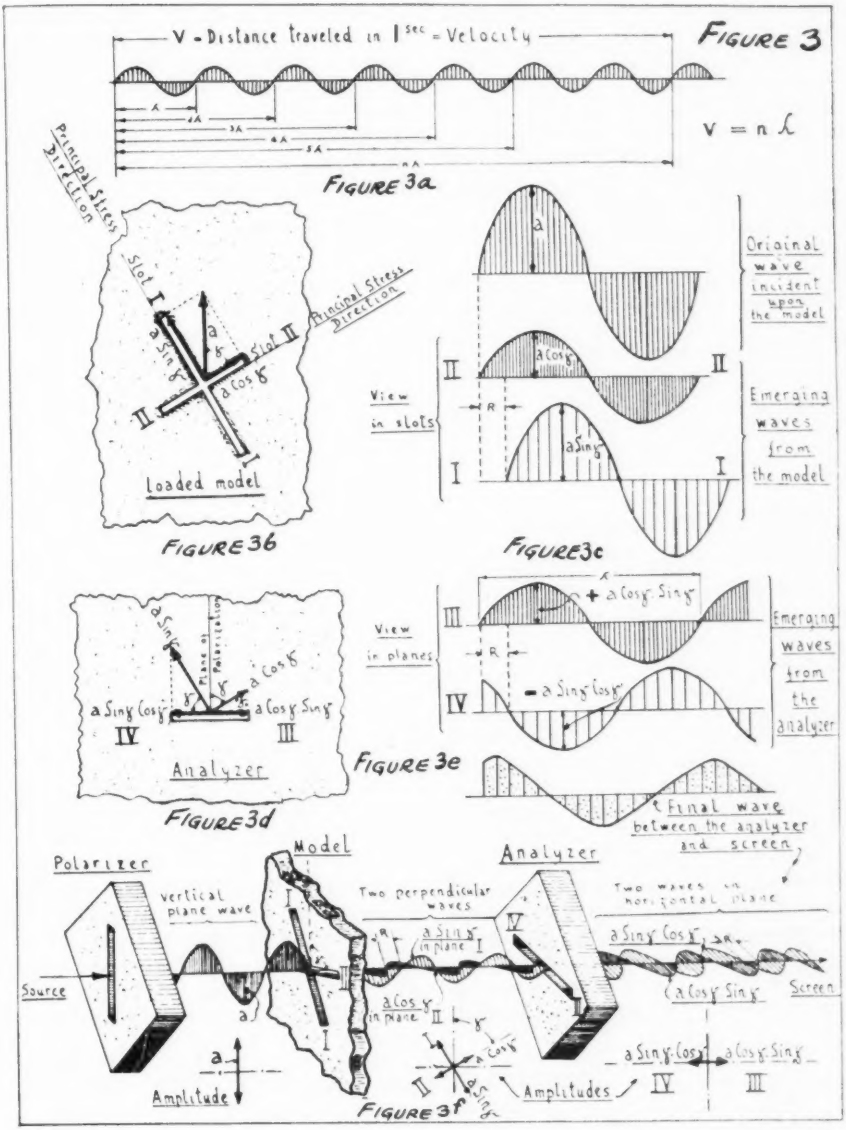


FIG. 3.

light is repolarized by a so-called "analyzer" in a plane normal to the original polarized beam that entered the specimen.

In the experiment under discussion the principal stress planes are looked upon as slots, following the method illustrated in Fig. 3. This illustration

was taken from a paper by N. Alexander (1936).

As shown in this figure the light emerging from the "analyzer" (slots III and IV of Fig. 3d) is made up of vectors of identical amplitude and frequency. These vectors are 180° apart and out of phase by R (Fig. 3e), the amount of the retardation caused by the difference of the principal stresses.

At every point on the free boundary of a two dimensionally stressed specimen the principal stress planes are one normal to the boundary and one parallel to the boundary, because on these planes the shear stress is zero.

The Babinet Compensator facilitates the reading of relative retardation at the extreme fibres. An explanation of its behavior follows.

Compensator Behavior

Suppose a specimen were given pure tension as shown in Fig. 4. One principal plane *ao* would have zero stress and the other plane *ob* would have stress P/A. In optically sensitive material one plane would retard the light more than the other, say *ob* greater than *oa*, and as stress is increased the relative retardation would increase. We might speak of a fast axis and a slow axis. Now suppose the stress were compression. The relative retardation would be reversed (*oa* greater than *ob*).

As illustrated in Figs. 3b and 3c, the reversal means that the light from slot I gets ahead of the light from slot II.

The meaning of the reversal can also be illustrated by a bakelite beam in pure bending. The light passing through the two slots (principal planes) at the neutral axis get through the specimen without relative retardation and the emerging beams are cancelled by the analyzer giving a dark band. Then on the compression side the light from say slot I is ahead of II while on the tension side the reverse is true.

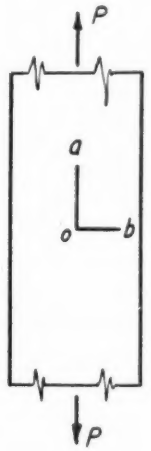


FIG. 4.

The stress interference pattern is as shown in Fig. 5 for pure bending.

Some transparent mineral crystals like tourmaline, mica, and quartz will take a polarized beam of light and repolarize it in two perpendicular planes. Retardation will be greater in one of the planes than in the other and a crystal of varying thickness placed between crossed polaroids will give an interference pattern due to differences in retardation.

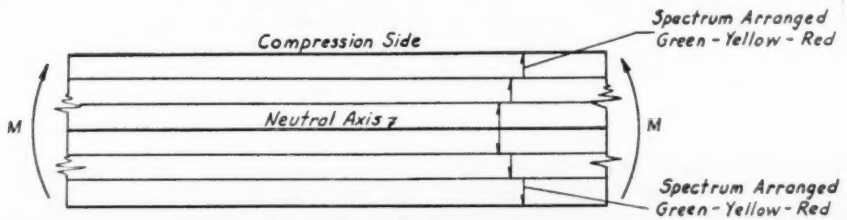


FIG. 5. Photoelastic pattern of beam.

In this sense the crystals act like stressed bakelite or glass.

By cutting wedges of quartz and placing them so that in one wedge slot I is perpendicular to slot I in the other we get a "Babinet Compensator," Fig. 6. The interference pattern of light through the superposed wedges is identical with that of a beam in pure bending. At a line $a-a$ where equal thickness of both wedges occurs the net retardation is zero and a "neutral axis" results. To the right of $a-a$ the pattern is like that of the compression side of a beam in pure bending and on the other side of $a-a$ the interference pattern is the same as for the tension side of the beam.

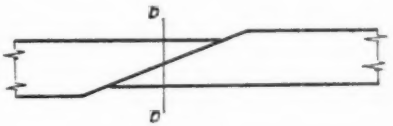


FIG. 6.

Now, if this Babinet Compensator is placed back of an unstressed, uniform rectangular section glass beam, and turned properly, the retardation pattern of the compensator appears as shown in Fig. 7. The distance d represents a relative retardation of one wave length.

If the beam is given pure moment M to cause compression in the top fibers, the glass becomes doubly refractive, and the total compression retardation above the neutral axis will be increased and shifted to the left as shown in Fig. 8. The shift is proportional to the retardation and stress.

The Experiment in Detail

An actual reproduction taken of the screen pattern is shown in Fig. 9. Measurements taken from this figure are recorded on the data sheet that follows.

$$\text{Stress } s = \frac{f}{d} K \frac{\lambda}{t}$$

λ = wave length of light
t = thickness of specimen
d = distance occupied by spectrum on screen
K = a constant for the material studied.

It is the boundary stress necessary to cause a retardation of one wave length in a specimen one wave length in thickness.

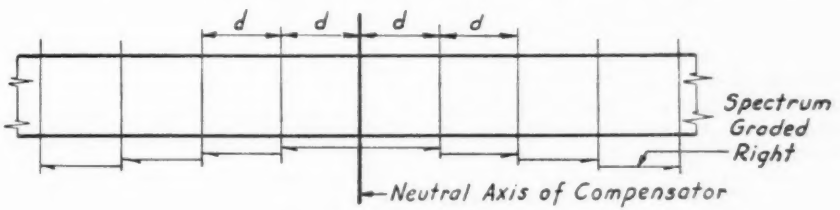


FIG. 7. Unstressed glass beam.

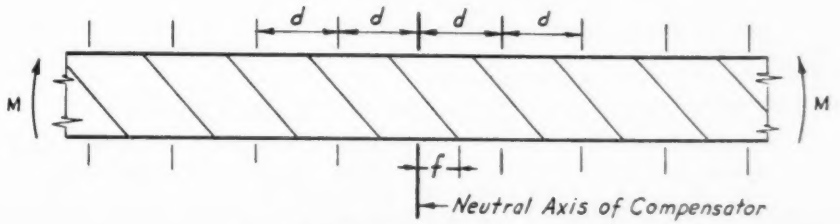


FIG. 8. Glass beam with moment M.

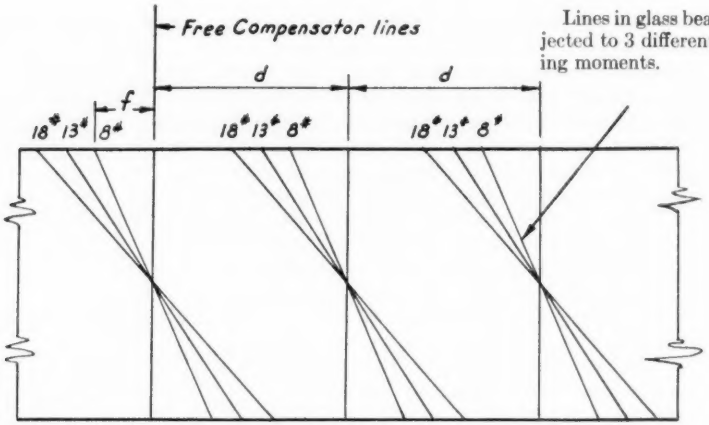


FIG. 9. Typical test pattern.

This formula for stress is Brewster's discovery that the stress is proportional to retardation.

To prevent confusion in computation the form of Brewster's law from which theoretical stress was figured was given to the class in the English system of units. The micrometer for measuring thickness and height were in inch units and the loads were in pounds.

White Light

In this work white light was used and the techniques employed were the same as for monochromatic light with the wave length that of the so-called "tint of passage." "During the transition from red to blue the complementary color is a dull purple which is very sensitive to small changes in $(p-q)$" (principal stress difference). "This color is called the tint of passage."* The wave length for this light is 5893 Angstroms, equal to .0000232 inch.

The form of Brewster's Law as used by physicists is:

$$\text{Stress difference in dynes/sq. cm.}^2 = \frac{n\lambda}{Ct}$$

where n is the number of wave lengths of retardation; λ is the wave length of the light used in centimeters.

C is Brewster's constant for the material, is in $\frac{\text{cm.}^2}{\text{dyne} \times 10^{13}}$. A value of 2.85 was used as C for the glass in this experiment.

t is the thickness of the specimen in centimeters. Since n is a pure number and since λ/t is a pure number, the conversion to English units is:

$$\text{Stress difference} = \frac{n\lambda}{t}\frac{\text{dyne} \times 10^{13}}{2.85 \text{ cm.}^2} \times \frac{1 \text{ gram}}{980 \text{ dynes}} \times \frac{1 \text{ lb.}}{454 \text{ grams}} \times \frac{(2.54 \text{ cm.})^2}{(\text{inch})^2}$$

The number of wave lengths retardation n in this experiment was f/d.

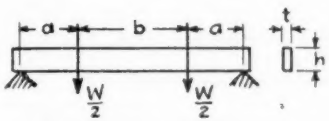
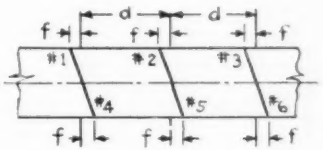
The final formula

$$\text{Stress difference} = \text{stress} = \frac{f}{d} 50.8 \times 10^6 \times \frac{\lambda}{t} \frac{\text{lbs.}}{\text{in.}^2}$$

DATA SHEET

Purpose: To measure stress by photoelastic methods in a plain rectangular beam.
Material: Plate glass
Condition: Annealed

* M. Frocht, "Photoelasticity," Vol. I, p. 169.



h = 0.249 in a = 1"

t = 0.253 in b = 3 3/4"

$I = t\,h^3/12$ = 0.000328"⁴

Stress = $K \frac{f\lambda}{d\,t}$ (A form of Brewster's Law) λ = Wave length = .0000232 inch

Tare = 3.5# d = Average color band distance = 1.20 in

K = psi stress that will cause one wave length retardation in material one wave length thick. $K = 50.8 \times 10^6$ #/in²

LOAD		BENDING MOMENT	NOMINAL STRESS	RETARDATION f							Optical Stress	Diff
Added	Total W	$M = \frac{W a}{2}$	$S = \frac{M h}{2 I}$	1	2	3	4	5	6	Aver.	$K \frac{f\lambda}{dt}$	%
5	8.5	4.25	1615	.46	.49	.48	.37	.37	.43	.43	1570	
10	13.5	6.75	2520	.72	.59	.68	.66	.68	.72	.67	2510	
15	18.5	9.25	3510	.94	.93	.81	.86	.87	1.03	.91	3500	

It will be noted that the nominal or computed stress is in good agreement with the optical stress found by the use of the Babinet Compensator. Theorists on elasticity prove that, if the material is isotropic, the nominal stress $Mh/2I$ is exact.

This agreement in values is in accordance with Brewster's discovery that retardation is proportional to stress differences.

Notched Specimen Experiment

The optical method was then used to obtain the factor of stress concentration in a notched glass beam, Fig. 10.

The image of the unstressed beam imposed on the compensator pattern appears as illustrated below.

If it is remembered that on the free boundary the principal planes (considered as slots) are one normal to and one along the boundary, shifted compensator lines due to loading can be interpreted.

The sketched image of the loaded specimen is shown in Fig. 11. The compensator can be "shifted" or "positioned" so that the free compensator lines remain vertical and with their original spacing, but the portions of the lines in the glass image, changed by stresses, can be brought to any desired position. The image in the glass of the compensator neutral axis AB can be brought to the low point of the notch where the principal stress slot is vertical as it is

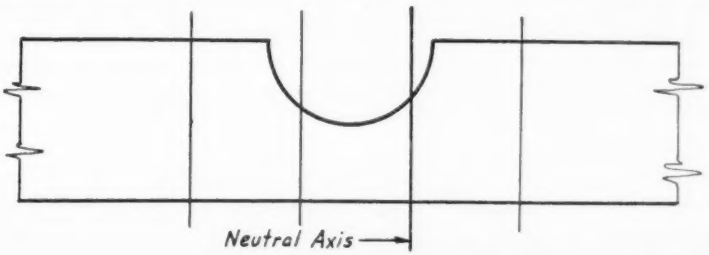


FIG. 10. Unstressed glass beam.

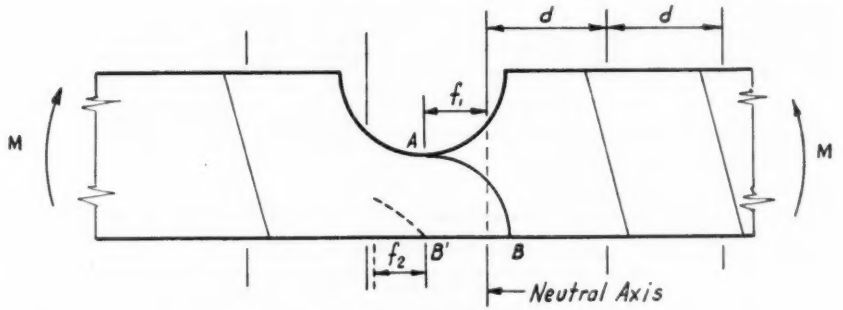
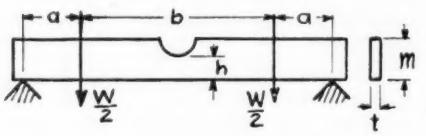


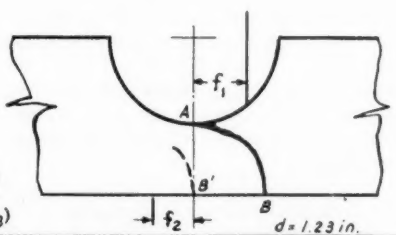
FIG. 11. Stressed glass beam.

in the compensator. The distance f is proportional to the stress at the base of the notch.

After measuring f, the compensator is again shifted until point B is brought to B' directly below the center of the notch and reading f_2 taken. Distance f_2 is proportional to the stress on the flat side opposite the notch. The data sheet material as obtained in this experiment is presented below.

The factor of stress concentration at the base of the notch averages about 1.17. This value is in fairly good agreement with values found using SR-4 Electric Strain Gage on a notched aluminum beam of the same ratio of h to m as in the glass beam.





h = 0.227" m = 0.494"

t = 0.255" I = $t\,h^3/12$ = 0.000248 $in.^4$

Stress $S_o = K\frac{f\lambda}{d\,t}$ = 3720 x (f_1 or f_2)

LOAD		BENDING MOMENT	NOMINAL STRESS	RETARDATION		OPTICAL STRESS S_o		FACTOR OF STRESS CONCENTRATION S_o/s	
Added	Total W	$M = \frac{W\,a}{2}$	$S = \frac{M\,h}{2\,I}$	Notch side f_1	Flat side f_2	Notch $\frac{K\lambda}{d\,t} f_1$	Flat $\frac{K\lambda}{d\,t} f_2$	Notch	Flat
#	#	"#	#/$in.^2$	in.	in.				
5	8.5	4.25	1946	.63	.43	2340	1600	1.20	.82
10	13.5	6.75	3070	.95	.66	3530	2450	1.15	.79
15	18.5	9.25	4230	1.33	.83	4940	3090	1.17	.73

Average factor at base of notch 1.17, at flat side .79

Standards and the Young Engineer

By THOMAS D. JOLLY

Vice President in Charge of Engineering and Purchases, Aluminum Company of America

Standards will have an ever-increasing importance. They will play an expanding role in the field of engineering and manufactured goods, in commerce, and in many other new fields. The will ultimately affect the production and sale of all goods.

That statement was made in January, 1945, by a group of first-line business executives. The Secretary of Commerce had called them into conference to advise him on a program for post-war standards activities. The business leader of the conference was Mr. Charles E. Wilson, then president of the General Electric Company, now head of the Office of Defense Mobilization.

The prediction, I think, has been amply borne out in the five remarkable years since it was made. It is a commonplace that standardization has been an essential factor in giving us our mass production, our free national market, and, hence, our high standard of living. Today, however, standardization has been carried far beyond anything we have previously known. Standards are being applied to production processes in almost every field, from electronics to the packing and shipping of fruit. They are more and more permeating the entire fabric of our industrial economy.

A Dominant Characteristic of American Economy

On the company level, standardization is now accepted as a basic and indispensable tool of management. Standards activities may be carried out through a company-wide technical committee (as at General Motors and Detroit Edison); they may be the responsibility of an entire division or department (as at General Electric, Eastman Kodak and the Radio Corporation of America); or they may be delegated as a function of the engineering department (International Harvester, Chrysler Corporation). Regardless of how the standardization is carried out, its usefulness is no longer a question in the minds of company engineers, purchasing agents and production men.

On the industry level, our trade associations and technical societies are doing important work in standardization throughout specific industries. Many of these organizations, particularly in engineering, have set up standards activities groups within their own structure. On the national level, American industry supports the American Standards Association as a clearinghouse of standards work. The ASA is one of 37 such national institutions throughout the world, and is the American representative among the 29 which make up the International Organization for Standardization. The federal government has a bureau and two divisions engaged exclusively in standards work. The armed services, which have always been leaders in the use of managerial standards ("Standard Operating Procedure" is one of the best-known phrases in military terminology), are now carrying out standardization projects of tremendous scope and importance, particularly in purchasing.

The points I want to make are simply these. Standardization is rapidly becoming the dominant characteristic of the American industrial economy. And

the importance of technical and managerial standards is more widely recognized today than ever before in our history.

It is my impression, however, that there is one place where the importance of standardization is not fully recognized. That is in the nation's engineering and business administration schools.

Standards Education in College

I do not mean to say that the professors and instructors of these schools do not understand or appreciate industrial standardization. I do not wish to imply that they are ignoring it. It would be almost impossible today to say very much on engineering subjects or management administration without taking up such matters as purchase specifications, manufacturing operations and processes, methods of inspection and testing, and the application of statistical methods to quality control. Examples of basic standards in these fields are those for screw threads, interchangeable machine components, and innumerable kinds of materials used in industrial production.

However, our American engineering schools, although they may deal with some specific subjects, such as standards for drawings and drafting room practice, with a few exceptions are not teaching industrial standardization as a specific course. Because they have failed to recognize the full significance of the standardization movement in this country, they are lagging behind industry and government in a field where they should be far out ahead.

These conclusions are based, first on an examination of the curricula of the colleges themselves, and, secondly, on an examination of a good many of the young engineers that they graduate semi-annually.

An inspection of the catalogs of our engineering and business administration schools shows that, with two exceptions, none is teaching any course or courses in industrial standardization. An examination of the graduate shows that he is a well and broadly schooled engineer. Never has any industry received such a well-trained engineer as ours is getting today. Nevertheless, he simply is not adequately informed on the theory, practice and application of standards, and his work shows it.

Why is this so? That is a question I must leave to you in education to answer. I do ask you, however, to skip the reason. "The curriculum is already overcrowded." If this subject has the importance that American industry seems to think it has (and it does), then that stock excuse has no validity.

The young engineer graduating into industry today is likely to lack, first of all, sufficient training in the fundamental art of writing standards specifications. He has not been drilled in the fact that standards should be written on a cooperative basis. The specifications he turns out, therefore, are likely to be badly written as specs, impractical, costly or impossible for the shop to follow. Or the young designer will create something special when a standard product, which will do as well or better, is readily available in the market at a great deal lower price. This means that his lack of knowledge of standards results in increased capital costs, money lying idle in stores inventory, and high maintenance expense.

The young engineer is likely, moreover, to have received standards training in his own field only. That would seem to be inevitable as long as standardization is taught as a subordinate part of other courses. Professors of engineering are specialists—very able specialists, to be sure, but specialists—in their own field. The highly integrated pattern of our industrial economy, of course, is such that standards training in one field only is quite inadequate. Standards enter into virtually everything a company designs, produces, inspects, sells and (most particularly) buys. The standards of definition, dimension, performance, testing and safety are all interrelated, and it is not enough to know one, two or even three of them.

The graduating engineer, finally, is likely to look upon standardization as merely a technical function, instead of standardization being as integral part of industrial and business management as well. He may have an adequate understanding of dimensional standards for steel sections for the building industry or of standardization of permissible stresses for steel structures, but he will be a rare young engineer if he has any conception of the administrative machinery by which standards are established and introduced into practice, or of the value of standards from the management point of view. If he has not learned this in college, there is, unfortunately, almost no place where he can be sent for special training in this field.

Standardization—A Powerful Economic Factor

Lack of knowledge of standards and training in standardization technique can handicap and perhaps personally embarrass the young engineer; but that is unimportant compared to the effect it can have on the company that hires him. Let me illustrate.

The literature of standardization is filled with hundreds of striking examples of great savings that companies have made through standardization. Here are two typical cases picked at random.

A company had been paying $60 per hundred for a certain type of bolt. It found that it could use a bolt complying with the American Standard that cost $9 per hundred.

A company found that it could reduce the number of metal washers it was using in its products from 1350 varieties to 150 standard types. It saved $25,000 in one year by doing this.

Now we can rejoice in the savings and added efficiency these examples demonstrate. But on soberer thought, the question arises: How did that happen? Why was the one company using a nonstandard bolt in the first place? How did the other company, in an age of standardization, come to be buying and storing so many unnecessary types of washers?

The answer is fairly obvious. Some engineer, or engineers, because there was no systematic standardization set-up in their company, designed them, requisitioned them, or ordered them. In one case, their error cost their company an annual waste loss of $25,000. In the other, it caused the company to pay $51 too much for every 100 bolts it used.

Such conditions may eventually be corrected—by someone who knows the importance of standardization. But the engineers who originally helped to create these conditions eventually rise to head their departments, divisions or even their companies. Unless they have mastered the theory and practice of standardization through practical experience on the way up, as is often the case, they may conceivably continue to permit conditions of this kind to develop on a far larger scale.

That such situations have been compounded on an industry-wide and national scale is becoming more and more apparent to all who study and report on the American industrial economy. *Factory Magazine,* for instance, has stated that American industry as a whole would gain about 650,000 man years of work a year if it used modern materials handling methods. The *Magazine of Building* recently estimated that more than a billion dollars a year could be saved by widespread use of dimensional coordination on the four-inch module. One prominent industrialist addressing the American Society of Mechanical Engineers last year declared that American business was losing about three billion dollars yearly in defective and rejected merchandise.

I said there are two exceptions to the statement that no American school teaches industrial standardization as a subject. They are Columbia University and Massachusetts Institute of Technology. Columbia's Department of Industrial Engineering, has, since 1947, held an annual course of 14 night classes on the practice

and application of industrial standardization. It is taught by Dr. John Gaillard, who is a lecturer on the Columbia faculty and a mechanical engineer on the staff of the American Standards Association. Dr. Gaillard also holds a week-long seminar on standardization twice a year, which has been attended by more than 100 conferees representing 73 organizations, including 63 private companies, two trade associations, an engineering college, five agencies of the armed services, and two foreign national standards bodies.

Last fall the Department of Business and Engineering Administration of Massachusetts Institute of Technology began the first college standardization course in this country that is taught as a full-term subject in a regular curriculum. It is conducted by Mr. Leo B. Moore, who was among those who attended Dr. Gaillard's first seminar on the subject back in 1947.

It is only a matter of time, I think, until we see such courses as these in most or even all our engineering and business administration schools. In normal circumstances, it would not matter vitally whether that time was a year away, or two, or five. Today, however, time is running short. We are in the middle of a world conflict in which it is not at all certain that we will win or even survive.

It seems obvious that to win that war, we must stop wasting our resources and make the best possible use of what we have. We must push to the limit the benefits of mass production—the supplying of a large volume of goods (both civilian and military) of sound quality at low cost.

Standardization can help us do all these things. It is not the sole remedy, certainly, for all our problems, nor even for all our production problems; but it certainly is an indispensable function that must constantly be applied to its full extent if American industry is to operate at anything like its potential level.

In developing this program, there is a tremendous job of education to do in government, in industry, in the armed services. Unfortunately, that educational program must begin with the educators themselves. The engineering and business administrative schools of this country, I am convinced, have both a responsibility and an opportunity in further exploring the industrial technique that has made this country productive and strong.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Retention of Mathematics in Mechanics

By JOHN W. CELL

Professor of Mathematics, North Carolina State College

A good point of departure in any consideration of teaching methods is an evaluation of the students to be taught. And since the first students we meet are freshmen, let us begin the discussion of Retention of Mathematics in Mechanics * with them.

The beginning freshman must learn to study. No longer can he get by with fifteen minutes of outside preparation on an assignment. He must increase his command of the English language as a basis for subsequent learning. He must master word problems. I trust that we all realize that we are, in a very real sense, teachers of English. And I suspect that you will realize as we proceed with this discussion that, as teachers of mechanics, you are all teachers of mathematics and physics as well.

The freshman's knowledge of basic algebra and geometry is likely to be fragmentary, if not actually faulty. He can probably transpose and cross-multiply and cancel (secant x/sine $x = \text{cat}/i = \text{a}$ one-eyed cat). But often he does not understand that one can multiply both sides of an equation by a number and have an equivalent equation; that actually one can add fractions only when they have the same denominator; that there are laws of exponents for multiplication and division but not for addition and subtraction; and so on.

This freshman may be from almost any level of his high school class, depending in part on the mode of selection exercised by the individual college. I am told that it is quite possible for the poor student in high school to know very little more at the time of graduation than the good student knows as a high school freshman. Nevertheless, at many colleges their diplomas command equal consideration.

The Learning-Forgetting Curve: Every college freshman (like everybody else) has an individual learning-forgetting curve. Fig. 1 gives a schematic explanation of the learning and forgetting that a typical student may well have experienced when he begins his study of mechanics, and later, mechanics of materials. When we discuss retention of any topic we must realize that we are dealing with human beings and their normal frailties.

Influence of Advanced Students: Another thing that affects the freshman student and his retention is the information that trickles back from upperclassmen. If juniors and seniors tell him that they are using algebra and trigonometry in their study of mechanics, they exert a more telling influence than any sales talk from teachers of mathematics can do. If, however, advanced students tell the sophomores about being penalized in a subsequent course because they used methods of calculus when the teacher wanted them to *use the formula*, then the reverse effect is achieved.

Fundamentals: There is a tendency in many departments to treat each student as though he were going to do graduate

* This paper contains a part of the writer's presentation at the ASEE Summer School for Mechanics Teachers held at Iowa State College in September of 1950. While the remarks are addressed to the subject of mechanics, the ideas are equally applicable in other fields of engineering.

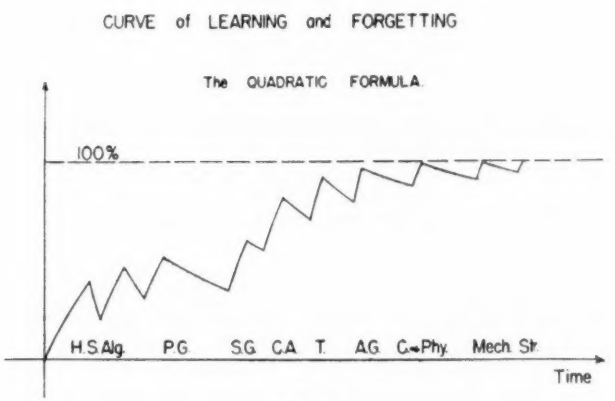


FIG. 1.

work in their fields of study. The teacher of mechanics of materials, for instance, is tempted to anticipate some of the subject matter taught in the senior courses in civil engineering. He finds time for the advanced topics by neglecting some of the fundamentals (as well as the uses of mathematics). This tendency to over-reach immediate topics is not surprising, since all teachers naturally like to teach the more advanced work. This complaint suggests another: It is unwise to try to exhaust every topic the first time it appears, as though it would not be treated again in other courses. For example, modern texts in physics contain all the information that was there when you and I took that course with the addition of new chapters on electronics and radioactivity and other recent ideas. Some of the problems in those physics texts dealing with mechanics and strength of materials would be more appropriate in the engineering courses that follow. This same criticism is valid for some recent texts in mathematics. They have all the material that was present thirty years ago, with the addition of new topics that engineering professors want us to teach; but we have no increase in time to teach the new material. I mention these two common defects in teaching because I believe that the piling on of too *much* or too *advanced* course material is an actual deterrent to remembering the fundamentals.

Continuity of Instruction: One device that can aid tremendously in retention is that of continuity of instruction. For example, in the freshman course in analytic geometry we teach the locus-derivation method for writing equations of curves. If we teach it with the realization that it is the student's first introduction to what is later to be stressed as the engineering or scientific method for the analysis and solution of engineering problems, then the student will be more receptive later to the engineering method.

This idea of continuity of instruction can take many forms. One approach would be for us to ask whether various modes of solution as traditionally taught really aim toward over-all objectives. For instance, consider the short-cut. It may be that a method of solution that takes several more steps and more time is a better method of solution than the short-cut. If so, should we cling to the time saver? One example of this can be had from solid analytic geometry. There is a good formula in the texts for finding the acute angle of intersection of two lines. Fig. 2 suggests a problem in which the student could apply this formula. But he can also solve the problem

(of finding the angle between the two guys) from another figure and by the use of the law of cosines. When he draws the required figure and applies the law of cosines, he is developing skill in a basic technique and in the manipulation of fundamental ideas. I believe that his finding the actual amount of the angle is not so important as the development of skill inherent in the longer method.

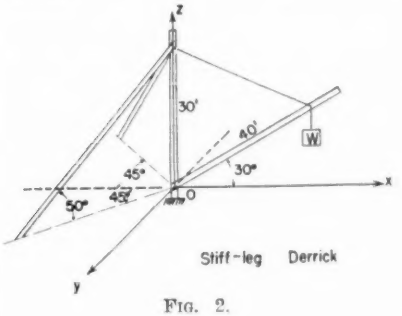


FIG. 2.

This particular figure could be used even in high school in teaching solid geometry, for the same reason that I like to use it in my freshman classes. It suggests other things besides the stated problem. It may stimulate the learning and retaining process because it implies future use of the topic at hand, and because it involves something that may be of much more interest to the student than the mathematics being learned. Judicious use of problems that foreshadow future uses (but do not teach subsequent ideas) can certainly stimulate classroom attention and the resultant retention of ideas. Apropos of this same figure, teachers of mechanics would do well to make specific reference to the law of cosines when they start teaching the vector law. Perhaps half of the students of every class (because of their learning-forgetting curves) need a brief review of the law of cosines, and the teacher would help their retention by careful use of this law rather than by starting them afresh with a new idea which they will equally forget.

Outlines: The periodic construction in class of an outline of the basic ideas already learned in a course, together with anticipation of what lies ahead, can help in this matter of retention. After more than twenty years, I well remember the outlines that appeared in Professor Seely's class in Strength of Materials, always with a diffierent sequence of oral questions that helped us to fill in the details of the outline.

Three Kinds of Mathematical Knowledge: One type of mathematics is that which the student should have at his finger tips, such as the quadratic formula, the trigonometric expansion for $\sin (A + B)$, or the derivative of $\sin u$ with respect to x. A second kind is that knowledge which the student should know where to find when he needs it. And a third body of knowledge is that which the student ought to be able to develop and *frequently should develop* on the basis of the ideas that he himself commands. This *habit* of reaching for tables of formulas at every opportunity certainly is not calculated to give to the student confidence and maturity. For example: Suppose that we were faced with the need of replacing $\cos 11x \sin 4x$ by a sum or difference of trigonometric functions. Every text on trigonometry and every set of tables gives a formula for doing this. But the following procedure has merit:

$$\sin (11x + 4x) = \sin 11x \cos 4x + \cos 11x \sin 4x$$
$$\sin (11x - 4x) = \sin 11x \cos 4x - \cos 11x \sin 4x$$

We subtract and obtain $\sin 15x - \sin 7x = 2 \cos 11x \sin 4x$, which is essentially the required formula. I can well remember seeing Dean Carmichael at the University of Illinois work out just such a relationship as he taught a class in advanced mathematics. I learned from that peerless teacher something of the art of basing instruction on fundamentals, and on the progression from the known fact to the desired solution. No teacher

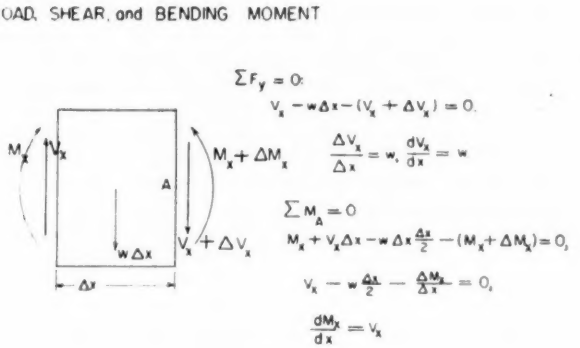

LOAD, SHEAR, and BENDING MOMENT
$\Sigma F_y = 0$:
$V_x - w\Delta x - (V_x + \Delta V_x) = 0.$
M_x
V_x
$M_x + \Delta M_x$
$\frac{\Delta V_x}{\Delta x} = w, \frac{dV_x}{dx} = w$
A
$\Sigma M_A = 0$
$M_x + V_x\Delta x - w\Delta x\frac{\Delta x}{2} - (M_x + \Delta M_x) = 0,$
$w\Delta x$
$V_x + \Delta V_x$
$V_x - w\frac{\Delta x}{2} - \frac{\Delta M_x}{\Delta x} = 0,$
Δx
$\frac{dM_x}{dx} = V_x$

FIG. 3.

need apolgize for making each step utterly clear, so long as he bases his presentation on the immediate fundamental. More important as a consequence of such instruction is that it engenders thinking and insight, and no amount of handbook referencing can do this.

The delta process, as taught in every course in calculus, is a good example of what mathematicians regard as a fundamental topic, and is one which may be considered profitably as we discuss continuity of instruction. Teachers of calculus utilize this process as the basis of almost every derivation throughout all of differential calculus. We obtain the derivative of a product by its use, the derivative of sin u, and so on. Thus the student is exposed repeatedly to this idea. His retention of mathematics, therefore, is greatly stimulated if later in undergraduate engineering the delta process is used wherever feasible. Fig. 3 is a typical figure taken from a text on Mechanics of Materials, except that the dimensioning is that of the delta notation rather than that of the differential. Derivations by both methods are equally correct. But proof by the delta process affords continuity of instruction. Moreover, *the delta-process derivation does not give rise to the false impression that certain approximations have been made "by neglecting infinitesimals of higher order."*

Continuity vs. Diversity: Mathematics teachers spend some time on moments while showing applications of integration. Simultaneously the physics teachers are discussing the idea of centroid and moment of inertia. And mechanics teachers, more than any others, use moments. How much time and emphasis are the proper function of each department involved in this instruction, and how much overlapping is good? And, more important still, is there continuity of instruction, or is there such diversity of presentation that the student is bewildered? Should mathematics teachers assign composite bodies and require the students to compute the centroids and moments of inertia? I do not think so; that is material that mechanics teachers properly stress. Should the physics classes utilize problems in motion such as that of a wheel with spokes for which the appropriate moment of inertia is computed by sundry rules? Again it seems to me that such ideas lie in the province of mechanics. Ideally, these three departments should synchronize their courses, leaving to the mechanics department the task of welding the total knowledge. If we have three radically different approaches, we will only promote the evil of "compartment" learning. The trend to appoint committees within a college to correlate course content and teaching can have salutary results.

Quizzes and Visual Aids: There are other devices that can aid the student in retention of knowledge. One of the best of these is the cumulative quiz, which we are using with good results at N. C. State College. On our mathematics quizzes about half the questions are on current material, and half deal with material that has preceded in the same term. Furthermore, we are learning how to slip in questions involving basic knowledge from earlier courses in the guise of problems on current material.

Still another method of aiding retention is the use of visual aids of various types—but only as teaching *aids*.

Interchange of Teachers Between Departments: Many teachers could be better prepared to help the student's retention if they had clearer insights into subsequent uses of the material they are teaching. The occasional interchange of teachers between related departments with frequent conferences attended by the exchange teachers and their colleagues can have a remarkable effect. Even frequent committee sessions on interrelating subject matter may be beneficial to the participants in terms of better insight into related material.

Summarization: I am aware that this discussion is not exhaustive. Indeed, no teacher can impose upon any other a total method. Each teacher, through his knowledge of the entire field of which he is a part (in this case engineering education), and through experience, develops his own teaching philosophy and techniques. I hope, however, that we can all agree upon the principles herein proposed. We ought to teach our several courses so that we incite a maximum amount of retention. We ought to teach so that the word filters back to the freshman and the sophomore that he had better learn his mathematics, his physics, and his English. We ought to seek continuity of instruction throughout the entire engineering curriculum. We ought not always to teach the short-cut method. We ought to teach toward objectives and not as though our course will have the last word on the subject. And we ought to strive for a better understanding of related material.

DR. DUGALD C. JACKSON

Dr. Dugald C. Jackson, President of the American Society for Engineering Education 1906–07, died on July 1, 1951 at his home in Cambridge, Massachusetts.

Dr. Jackson graduated from Pennsylvania State College in 1885 and for two years served at Cornell University as a fellow in electrical engineering. After sixteen years on the faculty of the University of Wisconsin, he joined the faculty at the Massachusetts Institute of Technology where he was Head of the Electrical Engineering Department for his full term of service.

Dr. Jackson served as a lieutenant-colonel of engineers during the first World War and in 1929, President Herbert Hoover appointed him as a representative of the United States at the World Engineering Congress in Tokyo.

In 1931 Dr. Jackson was awarded the Lamme Medal by the ASEE, one of many honors he received in his long and distinguished career.

TIMELY TIPS

Graphical Representation of Kinetic Energy Changes for an Adiabatic Irreversible Expansion

By WILLIAM B. NORDQUIST

Assistant Professor of Mechanical Engineering, University of Washington

The problem of interpreting a temperature-entropy diagram for an irreversible adiabatic expansion of steam in a nozzle is baffling to many students of Elementary Thermodynamics. Inspection will show that at any point, if momentary equilibrium is assumed, the steam will be drier than for the corresponding pressure point had the steam expanded isentropically. Drier steam means an increased specific volume, which, for a given nozzle cross-sectional area, would indicate a greater steam velocity. This argument, if carried through to the exhaust pressure, would lead to the paradoxical conclusion that friction will increase the useful work output of the vehicle.

The purely mathematical approach to this phenomenon, in terms of differential equations of reversible processes, is of small value. The average student is either being currently bewildered by the calculus, or, having recently completed the course, is not yet too sure of what he has learned or how he can apply it to a physical problem. From the standpoint of effective teaching, it is much more satisfactory to substitute a graphical analysis, even though it lacks, to a small degree, the complete rigorousness of an abstract mathematical approach.

The following method has been used quite successfully:

Assume that a perfectly designed frictionless nozzle (Fig. A) has concentric rings 1′—2, 2′—3, 3′—4 welded to it as shown. The steam entering at 1 would expand isentropically from $1' \rightarrow 1$, become momentarily turbulent from $1' \rightarrow 2$, expand isentropically from $2 \rightarrow 2'$, again becoming turbulent from $2' \rightarrow 3$, etc.

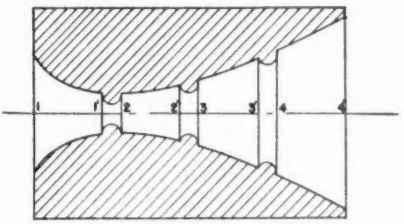


FIG. A

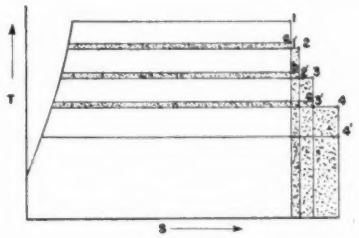


FIG. B

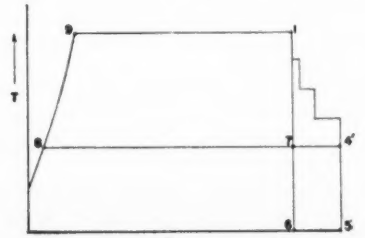


FIG. C

Now, considering the T-S diagram (Fig. B), the increase in kinetic energy of the steam as it expands from 1 to 1′ will be the entire area, both plain and dotted, to the left of 1—1′. As the steam flows past the ring, a portion of the useful kinetic energy (in this case the dotted area to the left of a—1′) will be changed to turbulent energy. For simplicity, it is assumed that the energy of this turbulence is dissipated and absorbed by the vehicle isothermally, and that as the steam leaves the down stream side of the welded ring, it is again in quasistatic equilibrium with point 2 in Figure B representing its state. From the General Energy relationships of an adiabatic expansion, the dotted area to the left of a—1′ is equal to the dotted area under 1′—2. The steam is again expanded isentropically from 2 → 2′ and then past ring 2′—3. As the vehicle reaches point 3, its useful kinetic energy is the sum of the areas to the left of 1—a and 2—b. The dotted areas to the left of a—1′ and b—2′ have been completely used up as turbulent friction and reappear as isothermal heat transfers under lines 1′—2 and 2′—3. The above arguments are repeated until the steam emerges from the nozzle at point 4′.

The enclosed area 1, 4′, 7, 8, 9, 1 of Figure C is representative of the useful kinetic energy of the vehicle leaving the nozzle, plus what had at one time been turbulent energy. This turbulent energy is proportional to area 1, 4′, 5, 6, 7, 1 (Fig. C). Subtracting this latter area 1, 4′, 5, 6, 7, 1 from the former area 1, 4′, 7, 8, 9, 1, will leave an area representative of the useful kinetic energy of the jet.

It can be seen from this that, because of turbulence and friction, the increase in kinetic energy, had the steam expanded isentropically from pressure 1 to pressure 7, is greater than the irreversible increase in kinetic energy by area 4′, 5, 6, 7, 4′.

By this means of presentation, several additional interesting facts can be pointed out to the students.

1. Not all of what was once turbulent energy is wasted. Almost all of the area 1, 4′, 7, 1 (Fig. C) was resalvaged for useful work.
2. Friction and turbulence in the adiabatic case are not nearly as disastrous at high temperatures as at low temperatures. Note that almost half of the area to the left of a—1 was re-used as useful kinetic energy, but only a small percentage of the area to the left of c—3 can be salvaged.

Occasionally, an exacting student will object to any sort of line from 1′ → 2, 2′ → 3, etc, on the T-S diagram because of the non-homogeneity of the vehicle. Usually, he can be placated by considering these isothermal lines to be made up of points representing momentary equilibrium of the vehicle as it is absorbing the effects of the decadence of the turbulent energy.

Cooperative Division to Hold Third Annual Mid-Winter Meeting

The Cooperative Division of the ASEE will hold its Third Annual Mid-Winter Meeting at Northwestern University, November 8th and 9th. The program is planned to be a part of the Technological Institute's program in the Centennial celebration of Northwestern University this year.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Monday, June 25, 1951 at Michigan State College, East Lansing, Michigan. Those present were: F. M. Dawson, *President,* H. H. Armsby, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, and B. Bowen.

Report of the Secretary

The Secretary presented a written report summarizing the year's activities. He reported that the General Education Board grant to the Southeast Section for research fellowships had terminated and that the balance of the funds will be returned to the General Education Board.

Report of the Treasurer

The report of the Treasurer was presented, including the tentative annual audit. The Treasurer stated that the income and expense statement showed a small net addition to surplus during the past year. However it would be necessary to draw upon the Special Projects Reserve Fund to the extent of approximately $400 for special projects conducted during the year.

There was a discussion as to how to handle the ECRC accounts, owing to the deficit which is offset by the inventory of unsold publications. A motion was passed to establish a revolving fund, with the following provisions: (1) The Executive Board is to set up an account for the Engineering College Research Council. (2) To this account will be transferred the balance in the ECRC reserve amounting to $1,315.03, (3) The Executive Board voted an additional $400 from the Special Projects Reserve to the new ECRC revolving fund, (4) All current cash deficit or unpaid bills for the year ending June 30, 1951, shall be charged against this new account (it is estimated that these amount to $1,635), (5) It is the desire of the Executive Board and of the Parent Society that the Research Council use this new account as an operating account to which will be deposited all receipts and from which all expenses will be paid, (6) The Executive Board also will deposit to this revolving fund the annual budget appropriation to the ECRC.

The Treasurer reported that the proposed budget for 1951–52 is considerably more stringent than the budgets of preceding years, owing to rising costs. The Society has been notified of a nine per cent increase in costs of publication of the JOURNAL. This item alone adds approximately $2,000 to the annual expenses of the Society. A motion to approve the budget was passed.

It was voted that a committee of the Society be appointed to solicit advertising for the *Journal of Engineering Education.*

Report of the Vice-Presidents

Vice-Presidents Armsby, Grinter, Terman, and Rosselot presented written reports on the activities of the Society's Sections and Branches, Divisions, Administrative Council, and Research Council. These are summarized in the minutes of the General Council meeting of June 25, 1951.

Fall Meetings of ECRC and ECAC—1951

The Board voted to hold the Fall meetings of the General Council, ECRC and ECAC in Houston, Texas, after the Land

Grant College meeting, which is to be held November 13–14.

Control of Questionnaires Used by ASEE Members Making Surveys

The Board discussed the problem of the burden placed upon administrative persons and faculty members by the numerous questionnaires which have been sent out by members in the name of the Society. It was the consensus of opinion that the Society should not attempt to control questionnaires as long as the ASEE name is not used, but that the problem should be brought to the attention of the members of the Society.

Location of 1953 Annual Meeting

The Board voted to hold the 1953 Annual Meeting at the University of Florida, the dates to be worked out with the host institution.

Dues of Faculty Members on Leave in Industry

The Secretary presented a letter which raised the question of dues of faculty members who are on leave from a university or college to work in industry. There is a standing regulation of the Executive Board that only members whose full-time activities are devoted to university work are entitled to the lower dues status. It was decided that faculty members on leave for short periods might be continued with dues status unchanged, but that if they continued their outside affiliation for a period of more than a year, they should be given the dues rating of industrial people.

Application for Affiliate Institutional Membership

The Board voted to approve the applications of Wentworth Institute and RCA Institutes for Affiliate Institutional Membership.

Additional Agenda Items

The following items were considered by the Executive Board and referred to the General Council for appropriate action. They are explained in the minutes of the General Council meetings of June 25 and 27, 1951.

1. Unity of the Profession.
2. The Society's participation in the civil defense program.
3. Resolution on postage stamp commemorating the centennial of engineering.

A meeting of the Executive Board of the American Society for Engineering Education was held on Wednesday, June 27, 1951, at Michigan State College, East Lansing, Michigan. Those present were: F. M. Dawson, *President,* H. H. Armsby, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, S. C. Hollister, J. H. Lampe, and B. Bowen.

Application for Technical Institute Branch

A motion was passed authorizing the Milwaukee School of Engineering to form a Technical Institute Branch. The Executive Board requested that the designation Technical Institute Branch be used in order to differentiate between branches of the Society in technical institutes and those in engineering colleges. It was pointed out that it has been the policy of the ASEE to prohibit any Branch from using this affiliation for advertising or public relations purposes.

New Projects

The Board voted that the officers of the Society be authorized to seek funds for two projects: (1) a survey of adequacy of standards in engineering education, and (2) the current project of the Committee for Improvement of Teaching.

Institutional Membership

Dean Hollister proposed that the Board authorize a study to be instituted by the officers relating to the development of Associate Institutional Memberships among industries. The Secretary reported that the Society has only six Associate Institutional memberships. It

was felt that now was an opportune time to get industry to take a more active part in the Society. No action was taken.

Advertising

The Executive Board voted to authorize a committee to solicit advertising for the JOURNAL.

Unity of the Profession

It was moved and passed that the following resolution be recommended for favorable action to the General Council.

"Your Executive Board believes that ASEE should be included in any group of societies which may unite in establishing any unity organization such as is contemplated in the report of the exploratory group representing this and several other societies. The Board recommends that ASEE cooperate fully with the professional engineering societies which are endeavoring to promote increased unity of the engineering profession, and that ASEE join in the formation of the proposed unity organization, *provided* that it is so constituted that ASEE as a constituent member society may retain its present requirements for membership."

Centennial Engineering Stamp

The Board voted to recommend to the Council endorsement of the issuance of a postage stamp commemorating the centennial of engineering, as proposed by the American Society of Civil Engineers.

Committees

It was voted to discharge the Committee on Industrial Safety, Hygiene, and Fire Prevention, as recommended by the Committee's officers.

The Executive Board voted to authorize the appointment of a Committee on Civil Defense.

Registration Fee at Annual Meeting

The Executive Board considered the problems of financing future Annual Meetings of the Society and recommended to the Council the adoption of a plan which is stated in the Council Minutes of June 29.

ECRC Committee on Contract Relations

The letter from the ECRC, respecting the appointment of a committee to represent the American Society for Engineering Education to study the problems of college and university contract relations with the federal government was discussed by the Executive Board. The following motion was approved.

"There is authorized the appointment of an advisory committee of the American Society for Engineering Education, responsible to the Research Council, to study intensively the problems of college and university contract relations with the federal government. This committee would be charged:

1. To prepare a statement outlining the consensus of university requirements;
2. To implement this statement by appropriate presentations in cooperation with other university groups concerned;
3. To discuss with federal officials on any problems of immediate concern during the period in which the statement was in preparation; and
4. To advise the appropriate agencies of the federal government regarding the existence and functions of the committee.

It is understood that the statement of university requirements should be circulated among all institutional members of the Society for their comments before publication."

Committee on Sections and Branches

Dr. Armsby presented the following recommendation of the Committee on Sections and Branches:

1. That the Committee on Sections and Branches be continued as now constituted.

2. That each Section be authorized to indicate the definite geographic area for which it wishes to assume responsibility, that the Chairman of the Committee on Sections and Branches conduct negotiations as required to avoid duplication and to insure that the entire country is covered; and that the resulting areas be submitted to Council for approval.
3. That following approval of definite geographic areas, each applicant for membership be given opportunity to indicate the Section with which he or she desires to affiliate, and that the same opportunity be given to all present members not already affiliated with a section.

The proposals were approved by the Executive Board.

Invitation to Membership on the Cooperating Committee of AAAS

It was moved that the officers be authorized to take appropriate steps to comply with the request from the AAAS Cooperative Committee on the Teaching of Science and Mathematics, if in their judgment such cooperation is desirable. The motion was passed.

Appointment of the Secretary

The Board voted to re-appoint Arthur B. Bronwell Secretary of the Society for the year 1951–52.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

College Notes

Engineering professors and instructors at the **State University of Iowa** have been spending time lately brushing up on their teaching theories. The results, the professors admit, have been surprising. Originally planned as a refresher course in the fundamentals of teaching, a program was designed for younger staff members of the university's college of engineering. It was part or a national effort sponsored by the American Society for Engineering Education and consisted of weekly meetings and panels extending from February to May. The program was carried out in cooperation with the university's college of education, which supplied many speakers on educational theory. On alternate weeks, the engineering staff formed a panel to discuss what the educators had presented the week before.

More than 5200 engineering research projects, representing annual expenditures of over $50.5 million, are now active in the engineering schools of American colleges and universities. These figures highlighted the bi-annual report of college and university research in the engineering sciences, prepared by the **Engineering College Research Council** of the American Society for Engineering Education, and released by Gerald A. Rosselot, chairman of the Council and director of the State Engineering Experiment Station at the Georgia Institute of Technology. The research projects, which cover all fields of engineering, represent the work of more than 11,500 faculty, graduate students, and research engineers, Dr. Rosselot reported. With only a few exception, he said, the projects are devoted to fundamental studies. Many are sponsored by federal government and state and industrial groups, but an important part of the activity is supported by general funds available for the educational programs of the institutions.

Minutes of General Council Meeting

A meeting of the General Council of the American Society for Engineering Education was held on Monday, June 25, 1951, at Michigan State College, East Lansing, Michigan. Those present were: President F. M. Dawson, H. H. Armsby, L. E. Grinter, G. A. Rosselot, F. E. Terman, C. L. Skelley, A. B. Bronwell, T. Saville, C. J. Freund, C. E. MacQuigg, R. S. Glasgow, C. A. Mockmore, L. O. Stewart, H. C. Spencer, F. J. Lewis, W. A. Koehler, T. T. Aakus, G. K. Palsgrove, M. T. Ayers, M. P. Capp, D. S. Clark, J. H. Rushton, C. E. Bennett, H. A. Bolz, R. L. Shurter, J. C. McKeon, H. W. Barlow, W. H. Carlson, H. H. Wheaton, R. D. Landon, H. K. Justice, H. R. Beatty, E. R. Walker, K. L. Holderman, L. R. Blakeslee, E. R. McKee, M. B. Robinson, W. M. Lansford, E. C. Clark, J. E. Thornton, R. Z. Williams, G. B. Hoadley, E. Laitala; and invited guests were: J. A. Hannah, J. Weil, C. Muhlenbruch, W. P. Kimball, L. G. Miller, W. R. Woolrich, and B. Bowen.

Report of the Secretary

The Secretary submitted a written report on the activities of the Society during the past year. He stated that the Society had received a letter from the Secretary of the State of Illinois that its request for incorporation as a non-profit corporation in the State of Illinois had been approved.

The Secretary announced the renewal of the agreement with the Westinghouse Educational Foundation, providing for a continuation of the Westinghouse Award on the same basis as the original contract.

The Secretary announced that approximately 550 new members were added to the membership rolls during the past year and that the resignations and deaths total 327. He stated that it appears likely that the membership is reaching a saturation point, but that there were certain areas of potential membership which had not been heavily canvassed. Motion to approve the Secretary's report was passed.

Report of the Treasurer

The Treasurer presented the annual audit, which showed a probable surplus of approximately $1100 in the year's operations. He stated that $400 would be used out of a Special Projects Reserve Fund which had been set up the previous year. He also stated that the General Education Board Research Grant to the Southeast Section of the ASEE expired in June of 1949 and would therefore be terminated. This would involve a refund to the General Education Board of $13,229, which would decrease the cash position of the Society by this amount.

The Treasurer presented the budget for 1951–52. He stated that the printing firm publishing the JOURNAL had announced a nine per cent increase in publication costs. This, together with other increased costs of operation, would make it appear as though the Society would operate at a barely balanced budget for the coming year, with no appropriation for special projects which might arise during the year.

The President summarized the report by stating that the financial position of the Society during the past year was quite satisfactory, but that it appeared probable that the finances would be considerably more stringent in future years if the present dues structure is maintained. A motion was passed to accept the Treasurer's report.

Report of the ECRC

Dr. Rosselot, Vice-President of the ASEE in charge of the Research Council, reported briefly on the two major projects which the Council had undertaken during the past year. These include: (1) a bi-annual *Review of Current Research,* and (2) the survey of University Research Potential. The latter was a cooperative endeavor with the Research and Development Board. Both publications have been completed and will be made available to the Society membership at a price to cover printing costs.

He reported that the bi-laws of ECRC had been amended to permit the formation of geographical sections of the ECRC and that a petition for the formation of a section in the Southeast Section had been presented.

He reported that the inventory of the Review of Current Research and the University Research Potential publications assured the Research Council of an income next year which would place the Council in a sound financial position.

Unity of the Profession

Dean Saville outlined the proposal for the Unity of the Profession organization. He stated that in his opinion the General Council should present some definitive recommendations which he could present to the Planning Committee as representing the official opinion of the Council.

Dean Freund emphasized the desirability of the ASEE's participation in the Unity organization in order to get a single spokesman for the entire engineering profession. Dean Saville stated that it is quite likely that the Planning Committee will consider other plans than those originally proposed and that the entire planning is still in the fluid state, but that it was necessary for ASEE members to make their wishes known now if they wished to have any influence in shaping the basic structure of the organization.

Engineering Manpower

Dean Saville summarized the accomplishments of the Engineering Manpower Commission. He stated that the Commission had received excellent cooperation from Mrs. Rosenberg, Assistant Secretary of Defense. However he stated that the views of Secretary of Defense Marshall on the problem of technical manpower are apparently opposed to those of Mrs. Rosenberg and that considerable opposition might therefore be anticipated from the Secretary of Defense.

Other Relations with Government

Dean Saville reported briefly on the National Science Foundation and the Point Four program. He stated that a program was being considered by the Office of Scientific Manpower for the furloughing of faculty members to government agencies on a two year rotation basis. This proposal is still in the tentative stage.

Report of Vice-President Armsby

Vice-President Armsby presented his written report. He spoke briefly of the effective cooperation which has been achieved through the formation of the Committee on Sections and Branches. He summarized the work of the regional conferences which had been organized by the ASEE Committee on Atomic Energy. The Atomic Energy Committee of the ASEE has recommended to the Atomic Energy Commission that a bibliography be published on basic materials which would be of interest to engineering educators. The Committee also recommended to the Atomic Energy Commission that they sponsor the publication of a source book on atomic engineering along the general lines of Gladstone's Source Book. The Atomic Energy Commission has agreed to undertake both projects.

Report of Vice-President Grinter

Vice-President Grinter reported on the summer school program for the past year,

including those sponsored by the Engineering Drawing Division, Humanistic-Social Division, and Mechanical Engineering (Thermodynamics) Division. He spoke of the outstanding success of the two summer schools which were sponsored by sections of the Society. These were the Fontanna Summer School of the Southeast Section and the University of Wisconsin Summer School sponsored by the North Mid-West Section.

He reported on the accomplishments of the Committee on Improvement of Teaching and stated that this Committee had met for two days prior to the Annual Meeting to consolidate its findings and prepare reports for presentation at the General Session. He stated that the Committee will now embark upon the preparation of a final report.

Report of Vice-President Terman

Vice-President Terman outlined the work of the ECAC during the past year. He stated that the Committee on International Relations of the ECAC had undertaken two major projects, one of these being the scheduling of an International Night Dinner at the Annual Meeting at Michigan State College. This dinner was attended by a number of engineering educators of foreign countries who were invited by the chairman of the Committee. The second project was the formation of a Commission on Engineering Education to visit Japan and consult with educators and the Japanese government on engineering education. He also outlined the Annual Meeting programs on engineering manpower and the executive session of the ECAC which were scheduled for the Annual Meeting.

Membership Qualifications in the Society

The Secretary stated that the constitution of the Society specifies the requirements for individual membership in the society as follows: "Persons who occupy responsible positions in engineering instruction, research or practice," and then leaves the door open with the additional stipulation "and other persons interested in engineering education." He stated that this wording of the constitution gave the Secretary's office no authority to question the membership qualifications of anybody applying for membership in the Society and that numerous applications had been received from persons requesting membership in the Society whose affiliations and interests were not in any way associated with engineering education or engineering. He stated that the purely mechanical routine of submitting the list of new members to the General Council for approval did not constitute any basis of selection, since a majority of the Council members approved the list without discrimination. Professor Clark suggested the advisability of establishing minimum qualifications for membership in the Society in order to clarify the eligibility of applicants. No action was taken.

Cooperation with High Schools

Dean MacQuigg mentioned the close cooperation between several of the engineering colleges in Ohio and high schools throughout the state. He stated that this had been effective in increasing engineering enrollments and also in conveying to the high school teachers the educational needs of the universities and colleges. Dean Freund raised the question as to the possibility of soliciting membership of high school teachers in the ASEE in order to further this objective.

Civil Defense

Dean MacQuigg reported briefly on the Civil Defense meeting in Washington, D. C. He stated that there was general public apathy regarding the preparation for an atomic bomb attack and that the consequences of such an attack, even though remote, are so serious as to make it imperative that careful advance planning be undertaken throughout the entire country. Professor Carson and President Dawson both spoke of specific planning which had been undertaken in their areas of the country. It was emphasized that industrial targets would

probably be the first objective of an enemy attack. The suggestion was made that an article be prepared for the JOURNAL outlining the preparations which were being made in some of the areas where advanced planning had been undertaken.

Committee on Teaching Aids

Professor Muhlenbruch reported on the progress of the Committee on Teaching Aids and stated that $4600 had been collected from industrial sources to defray the expenses of this committee and that an attempt would be made to get additional funds. He stated that reviewing committees had been appointed in several curricular areas and the review work would start in the near future.

Committee on International Relations

Dean Woolrich reported briefly on the International Night Program and the Commission on Engineering Education to Japan.

He also stated that there was need for getting information to our government and to agencies which are advising foreign students on schools in this country, since most of these agencies send engineering students to a relatively few colleges which they know about, to the exclusion of many other good engineering colleges in this country.

He also raised the question as to whether or not the ASEE should request a representative on UNESCO. He pointed out that our Society had a representative several years ago, but that our membership was on a rotation basis. The question was raised as to whether or not the ASEE should not request a continuing membership in UNESCO rather than a rotational membership. It was recommended that Deans Woolrich and Croft cooperate in the preparation of a specific proposal to be presented to UNESCO, requesting a continuing membership of the ASEE.

* * * * * *

A meeting of old and new members of the General Council was held at Michigan State College, East Lansing, Michigan on Friday morning, June 29, 1951. Those present included: F. M. Dawson, *President*, H. H. Armsby, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, F. E. Terman, S. C. Hollister, J. H. Lampe, Thorndike Saville, C. J. Freund, R. T. Landon, M. P. Capp, L. D. Jones, W. W. Dornberger, J. McKeon, H. W. Barlow, W. H. Carson, C. E. Bennett, G. B. Hoadley, W. Allan, H. A. Bolz, H. P. Adams, L. O. Stewart, F. J. Lewis, C. O. Harris, W. P. Kimball (visitor), T. H. Morgan, E. R. McKee, H. K. Justice, W. A. Koehler, C. A. Brown, H. R. Beatty, S. E. Winston, T. G. Miller, M. T. Ayers, H. H. Wheaton, L. G. Miller, G. K. Palsgrove, B. Robinson, H. C. Spencer, E. W. Lehmann, D. Hunt, E. Laitala, E. C. Clark and B. Bowen.

The President announced the following actions taken by the Executive Board at its meeting on June 27, 1951. Details of these actions are given in the Executive Board Minutes.

1. The Board approved the request of the Milwaukee School of Engineering to form a Technical Institute Branch.
2. The Board authorized the appointment of a committee to develop the possibility of getting more Associate Institutional (industrial) members.
3. The Board voted to discharge the Committee on Industrial Safety, Hygiene and Fire Prevention at the suggestion of the Committee Chairman.
4. The Board authorized the appointment of a new Committee on Civil Defense.
5. A committee was authorized to study the problems of college and university contract relations with the Federal Government.

ECRC Resolution

The ECRC resolution to form a committee to study college and university contractual relations with the Federal Government, as modified by the Executive

Board on June 27, was read to the Council.

Centennial Stamp for Engineering

It was moved and passed that the recommendation of the Executive Board to endorse the issuance of a Centennial postage stamp be accepted by the Council.

Unity of the Profession

The Secretary read the recommendation of the Executive Board at its meeting on June 27, respecting the Society's desire that any Unity of the Profession Organization should permit the Society to participate without changing its membership qualifications. The Council voted to accept the resolution and to have the President appoint a committee to study the problem and formulate specific proposals. This committee is to report back to the Council at its next meeting in the fall.

Participation in UNESCO

The following resolutions submitted by the Committee on International Relations was passed:

"Whereas engineering education is one of the most essential factors in the upbuilding of any national economy, and Whereas the American Society for Engineering Education represents the united organization of education in all of the branches of engineering, including civil, mechanical, electrical, mining, chemical, aeronautical, architectural, ceramic, petroleum, industrial, geological and agricultural instruction and research—and Whereas the present plan of occasional representation on UNESCO is entirely unfruitful of sustained aid to its program—Be it resolved that we request the authorities of UNESCO for the appointment of a continuing representative on the UNESCO Councils from the American Society for Engineering Education—And that the Council of the American Society for Engineering Education authorize the President to actively pursue and negotiate with UNESCO to make such continuing representation possible."

Registration Fee

The following recommendation of the Executive Board at its meeting on June 27, regarding charging of registration fees at Annual Meetings, was passed by the Council.

"The host institution is to submit to the Secretary of the Society a budget showing their anticipated income and expense and also indicating the anticipated deficit. The President and Secretary of the Society are then authorized to set a registration fee to be charged by the Society, this fee not to exceed $4.00 per person, with no additional charge for other members of a family. The host institution will be reimbursed out of this fund for such items in the deficit as appear appropriate to the President and Secretary. Any amounts collected through this registration fee in excess of the expenditures authorized will be the property of the Society and will be set up in a reserve fund for future conferences. This registration fee should be charged by the Society, although the host institution may collect the money at the time of registration and report to the Society the amount collected."

Universal Military Training

A motion that the Manpower Committee be authorized to make a statement of policy on universal military training was discussed and passed.

Life Membership

The following persons meet all of the requirements for life membership in the Society and the Council voted to grant them life membership: H. Baum, G. W. Case, W. W. Carlson, M. I. Evinger, F. M. McCullough, L. O'Shaughnessy, E. B. Paine, J. E. Perry, J. R. Price, J. C. Rathbun, C. A. Schneider, E. B. Smith, W. R. Spencer, A. C. Stevens, V. T. Stewart, H. Tilghman, P. H. Underwood.

Resignations

The Council voted to drop the members of the Society who were delinquent more than two years in dues.

English Division Summer School

The English Division requested permission to hold a Summer School two days preceding the Annual Meeting in June, 1952. The matter was referred to the Vice President in Charge of Instructional Divisions for consideration.

Other Business

A comment was made that several members of the Society have expressed the desirability of providing a better outlet for the expression of opinions to the General Council and Executive Board. The matter will be placed on the agenda for the next Executive Board meeting.

Appreciation to Retiring Officers

It was moved that the Council express their deep appreciation for the excellent service of the retiring officer. Motion passed.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

College Notes

Jess Harrison Davis, president of Clarkson College of Technology, has been elected to succeed Harvey Nathaniel Davis, (no relation) as president of **Stevens Institute of Technology.** The new president is the fourth in the 81-year history of the college and will assume his duties September 1, 1951, according to Willis H. Taylor, Jr., Chairman of the trustees. The new president has had a varied and distinguished career as an engineering educator and industrial consultant. He was graduated from Ohio State with a degree in science in 1928 and received his master's degree there in 1933. In 1949 he received the degree of doctor of science from St. Lawrence University. His industrial career has included service with Ohio Bell Telephone Company, Alabama Power Company, American Locomotive Company, and Foster Wheeler Corporation. He has served as consulting engineer for Hydraulic Controls, Inc., New York Air Brake Company, D. M. McBean, and De Wolf Furnace Corporation. He is presently on the board of directors of the Niagara Mohawk Power Corporation. The career of Dr. Jess Davis as an educator started in 1929 when he went to Clarkson College as an instructor in mechanical engineering. By 1940 he became a full professor; in 1946, dean of administration; and he was made president in 1948. During a two-year interval, he served as professor and head of the department of mechanical engineering at the University of Louisville's Speed Scientific School.

Reed College, of Portland, Ore., has associated itself with **Rensselaer Polytechnic Institute** in offering scientists and engineers a broader basis of general education than is obtainable in the usual four-year course. Reed is the twelfth center of the liberal arts to join the program with Rensselaer, but is the first Pacific Coast college to participate. Under the plan students may take three years of liberal arts work at Reed, with emphasis on basic sciences and mathematics, before entering Rensselaer for two additional years of concentrated work in a selected field of science or engineering. Five years of satisfactory progress will earn degrees from both institutions.

Fifty-Ninth Annual Meeting
American Society for Engineering Education

The Fifty-ninth Annual Meeting of The American Society for Engineering Education was held at Michigan State College, East Lansing, Michigan, June 25-29, 1951. Over 1600 members and guests registered. Three general sessions and approximately 70 conferences of Councils, Divisions and Committees were held. F. M. Dawson, Dean of Engineering, State University of Iowa, and President of the Society, presided.

The first general session on Tuesday morning was sponsored by the ECRC and was presided over by Vice President G. A. Rosselot. Dr. E. A. Walker, Executive Secretary of the Research and Development Board, spoke on "The Nation's Balance Sheet in June, 1951," and Dr. A. F. Spilhaus, Dean of Engineering at the University of Minnesota, spoke on "Research and Development: The Nation's Potential in Educational Institutions." The concluding speaker was Dr. A. A. Potter, Dean of Engineering at Purdue University, who gave an address on "National Science Foundation Developments."

The second general session was held on Wednesday morning and was presided over by Dr. H. H. Armsby, Vice President of the Society, who introduced Dr. J. A. Hannah, President of Michigan State College, whose address was entitled "Lustre or Glitter?" Dean F. M. Dawson followed with his Presidential Address, "Engineering Education—A Bridge Between Ignorance and Understanding." Secretary A. B. Bronwell then presented his yearly report.

The Nominating Committee, represented by C. E. MacQuigg, presented the following slate of Officers. Upon motion, they were unanimously elected.

For President, one year, S. C. Hollister, Cornell University;

For Vice President in Charge of General and Regional Activities, two years, M. M. Boring, General Electric Company;

For Treasurer, one year, C. L. Skelley, Macmillan Company.

The ECAC elected Dean J. H. Lampe, Dean of Engineering, North Carolina State College, as Vice President of the ASEE and Chairman of ECAC. The continuing Vice Presidents are G. A. Rosselot and L. E. Grinter.

The final event was a panel discussion of the Committee on Improvement of Teaching. Dr. L. E. Grinter, Vice President of the ASEE, acted as moderator. The panel members included H. P. Hammond, A. P. Colburn, J. F. Calvert. A discussion period followed.

The third general session, sponsored by ECAC, was presided over by Dean J. H. Lampe, Secretary of the ECAC. Dean Lampe expressed the thanks of the ECAC to all of the staff and those at Michigan State College who had a part in making the meeting so successful. Dr. M. H. Trytten, Director of Scientific Personnel, National Research Council, presented an address on "Present Status of the Problem of Scientific and Engineering Personnel." He was followed by Don G. Mitchell, President of the Sylvania Electric Products, Inc., who spoke on "America's Industrial Strength and Its Technical Manpower." Carey H. Brown, General Superintendent, Eastman Kodak Company, and Director of the Engineering Manpower Commission of the E.J.C., spoke on "The Engineering Manpower Commission of the E.J.C." This

was followed by a short question and answer period.

The Annual Banquet was held on Thursday evening with President Dawson presiding. He introduced the Officers of the Society and expressed thanks to President Hannah for the hospitality of Michigan State College. Dr. Hannah presented a gavel to President Dawson. The Speaker for the Banquet was Dr. H. G. Bennett, Assistant Secretary of State in Charge of Point Four, and President of the Oklahoma A. & M. College, who spoke on "Engineering Contributions to Underdeveloped Areas." The Lamme Medal was presented to Allan R. Cullimore of the Newark College of Engineering and the George Westinghouse Award was presented to Glenn Murphy of Iowa State College.

The following resolution of thanks to Michigan State College was read by Dean A. A. Potter, Chairman of the Resolutions Committee:

"The American Society for Engineering Education, and especially its members and friends attending its 59th Annual Meeting, extends to our gracious host, the Michigan State College, our sincere thanks for the very extensive and effectual efforts that have been made for our comfort and pleasure, as well as for the attainment of the professional aims and purposes of our meeting.

To President John A. Hannah, to Dean Loren G. Miller of the School of Engineering, and to Professor W. E. Libby, General Chairman of the Local Committee on Arrangements, and numerous associates and assistants especially we extend our sincere appreciation.

In the long history of the meetings and conventions of this Society, the 59th meeting at East Lansing will stand out as one of the most successful and enjoyable.

(Signed) HAMMOND
SAVILLE
POTTER"

It was moved and seconded that the Society authorize the Secretary to send greetings and felicitations to Dr. and Mrs. D. C. Jackson, who were not able to be present. Dr. Jackson was the oldest living Past President of the ASEE.

President Dawson announced that the 1952 Annual Meeting would be held at Dartmouth College in Hanover, New Hampshire during the week of June 23–27.

Officers for 1951–52 were read by President Dawson who then called the meeting adjourned.

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute		E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5 or 12, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Capitol Radio Engineering Institute	Oct. 2, 1951	W. Oncken, Jr., Bureau of Ordnance
New England	University of Rhode Island	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Wisconsin	Oct. 5 & 6, 1951	K. F. Wendt, University of Wisconsin
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	Seattle		T. H. Campbell, University of Washington
Pacific Southwest	Los Angeles San Francisco	April, 1952	S. F. Duncan, University of Southern California
Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College		R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Clarkson College	Oct. 5–6, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

The Engineering Shortage Continues*

By S. C. HOLLISTER

Dean, College of Engineering, Cornell University
President ASEE

Last autumn a survey was made by the Manpower Committee of the Society to ascertain the outlook for engineering graduates in the immediate future. The result was that the freshman class was found to be substantially below that of 1949—a drop of about twenty per cent.

During the winter, much publicity was given to the shortage and its consequences upon the welfare and security of the nation. Special attention was given to informing high school principals and counselors concerning the great need for engineers. It was noted that instead of a pre-war rate of 5.8 per cent of male high school graduates who entered engineering schools, only 4.8 per cent elected this profession in 1950. Many hoped that the effort to inform secondary school officials of the situation would result in a larger freshman class in the fall of 1951.

As of June 1, 1951, the Manpower Committee made a survey of the 34 colleges that had participated in last fall's survey, to obtain the best estimate of the size of the freshman class of this coming fall. The result of this survey indicated that the expected class would be of the same size as that of last fall. Thus it appears that during the last year there has been no appreciable increase in the percentage of high school graduates desirous of entering the study of engineering.

There is little doubt that a variety of factors are responsible for the sustained low rate of students entering upon engineering. Before the outbreak of war in Korea, there was a much-published and mistaken anticipation that there would be a great over-supply of engineers; and to some extent this notion still lingers. In some quarters high school guidance counselors are reluctant to advise a boy to take an engineering course when there is only one chance in two that he may graduate (not realizing, no doubt, that the same ratio applies to collegiate work as a whole). Interesting careers for boys with similar aptitudes are developing in other fields. The generalization of high school training may not provide the necessary entrance requirements for engineering unless the choice is made early; and some boys do not reach a decision soon enough. These factors, and no doubt others, tend to restrict the number that may enter engineering from high school. The writer believes that any substantial increase in the number so entering will be slow in maturing; but also that it is essential to work diligently toward achieving this end.

Need for Engineering Graduates

About a year ago the writer was brash enough to make an estimate of the annual need for engineering graduates, and placed the figure at 30,000. The Bureau of Labor Statistics had previously estimated the need through the 1950's as gradually rising from 18,000 to 22,000 over that period. This agreed with the pre-war trend of engineering graduates given in the writer's paper in this JOURNAL in March 1949. Allowing for 10,000 needed by the armed force as engineering specialists, estimated from the Report, for a 3½ million man military

* Presented before the ECAC, at East Lansing, June 1951.

force, gave an average total over the period of 30,000. This did not, of course, make any provision for utilizing engineers in positions in which no engineering training is required. At the time, some thought, and time proved, that this was far too conservative a figure.

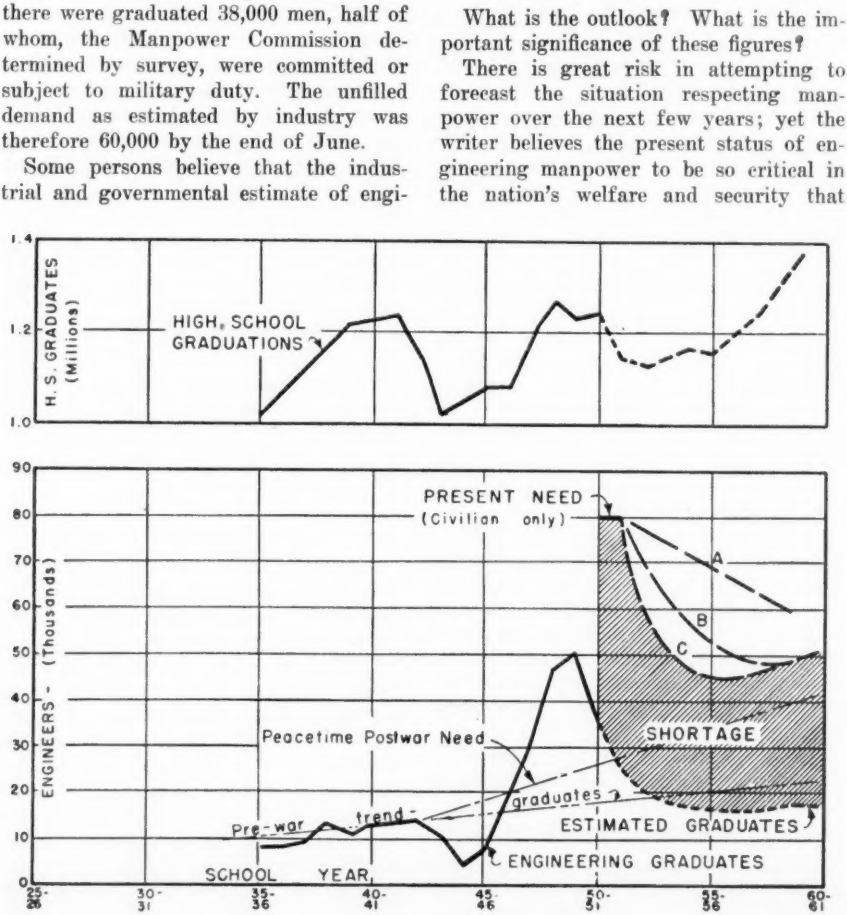
Early in June 1951 the Engineering Manpower Commission made a survey of 378 companies and government agencies, to determine their immediate need of engineers. The result of this survey indicated a total national need of 80,000 engineers, quite independent of those needed in uniform. Against this need there were graduated 38,000 men, half of whom, the Manpower Commission determined by survey, were committed or subject to military duty. The unfilled demand as estimated by industry was therefore 60,000 by the end of June.

Some persons believe that the industrial and governmental estimate of engineers needed is too high; that it is not a shake-down figure of real need. I can only say to this that many industries expressly stated their estimate was not inflated and that it was realistic. The fact is, furthermore, that there is no other dependable figure available, and no way to get one except by the method employed in obtaining this one. Even if one discounted the total figure by 25 per cent, or 20,000, there is still no comfort in the resulting unfilled shortage of 40,000.

Significance of Statistical Evidence

What is the outlook? What is the important significance of these figures?

There is great risk in attempting to forecast the situation respecting manpower over the next few years; yet the writer believes the present status of engineering manpower to be so critical in the nation's welfare and security that



every means available should be utilized to make adequate preparation for the future. Appraisal must be made with what evidence is at hand, without awaiting the elusive and practically unattainable perfect data.

The first factor of importance (see chart) is that there is a wholly inadequate supply of engineering graduates to meet the ultraconservative estimate of need of 30,000 per annum. The best efforts at increasing interest of high school graduates may add 4000 or 5000 to the annual graduations in engineering—but not before 1956. With the addition of 5000 that year the total graduations would be only 22,000.

The second factor of importance is that at present enrollments, and with no withdrawals for military service of any engineering students, there will not be enough graduates by and after 1953, at least to 1961, to meet the peacetime need as conservatively estimated by the Bureau of Labor Statistics, the shortage being at least 20 per cent.

The third factor of importance is that during the post-war four years prior to Korea, 149,000 were graduated and employed. This is a greater rate than that of the pre-war years upon which the Bureau of Labor Statistics based its peacetime estimate for the 1950's, by nearly 90 per cent. A conservative estimate of post-war peacetime need would appear to be 30,000.

The fourth factor of significance is that the industrial and governmental *civilian* need of engineers is far greater that the graduating class of 1951 (38,000). Whatever the military requirements for engineers may be, they are not available except by taking men from indutry; thus further intensifying the needs of industry.

The fifth factor of importance is that all considerations of need are based upon the current pattern of utilization of engineers by industry and government. The first step toward bringing need and supply toward better agreement will be to *change the pattern of utilization* through spreading the engineer's work over a greater range, and thereby lessening the need. The extent to which policy decisions by industry and government can in this way achieve a modification will determine the extent of the reduction of need (see curves A, B or C, on chart). In any case, it does not now appear that by any present or likely pattern of utilization or available source of supply the need and supply will be brought into balance over the next decade.

The Engineering Manpower Commission of the EJC: Its Objectives and Activities

By MR. CAREY H. BROWN

Chairman, Engineering Manpower Commission, Engineers' Joint Council

Cooperation of the American Society for Engineering Education with Engineers Joint Council in the formation of the Engineering Manpower Commission is most appropriate and timely. The Commission consists of three representatives of ASEE, Mr. Armsby, Dean Hollister and Dean Saville, and three representatives of each of the constituent societies of Engineers Joint Council, namely, the Mechanical, Civil, Electrical, Chemical, and Mining and Metallurgical Engineers. The Commission's headquarters are located with EJC in the Engineering Societies' Building in New York City. Mr. T. A. Marshall, Jr. is Executive Secretary. Incidentally, it seems to me that the EMC is a very good illustration of the ability of the engineering profession to act in unity when the need arises.

Failure or inability to foresee or to provide for the tremendous industrial and scientific growth of the Country since World War II, the demands of the present defense program and the coincidence of the passing of the G. I. college training program with the arrival at college age of the meager boy crop of the early thirties are main causes of the present shortage of engineers.

A survey in June 1951 (the present month) of the needs of 378 companies and government agencies shows that about 80,000 engineers are needed now exclusive of the needs of the military. When the current graduating class of 38,000 is absorbed there will still be an unfilled demand for 42,000 engineering graduates. However, a recent study of the 1951 class of engineering graduates showed that the military, through R.O.T.C. and reserve programs, and through the Selective Service System, will siphon off about 19,000 engineering graduates. The actual unfilled demand will then be for more than 60,000 engineers.

The urgent need for engineers cannot be met through the current sources of supply. The 1952 graduating class will be only about 26,000; 1953 about 17,000; 1954 probably even less than 1953.

Causes of the Shortage

The increased complexity of our industry and the development of new technological areas such as atomic energy, antibiotics, jet propulsion, electronics, etc. have caused a definite upturn in the use of engineers and scientists quite independent of mobilization. The ratio of engineers to direct labor has been increasing steadily since 1890. It now stands at about 1600 engineers per 100,000 workers according to the Bureau of Labor statistics and there is no sign yet that the relationship has commenced to level off.

The present partial mobilization has caused another sharp increase in the demand for engineers to speed up and improve the design, development, and production of the implements of modern warfare and other essential defense and civilian needs, and for the expansion of existing plants and facilities so vital to the national defense. Superimposed on this, is the loss of technical manpower

in industry as the result of the call of reservists to the service and the demands of Selective Service.

It is not possible to determine from the answers obtained whether the sharp increase in demand is due to the tooling-up needs of a partial mobilization, or because of the extreme technological advance of the past several years and the increased use of engineers and scientists by various organizations and agencies. There is some reason to believe that much of the increase may be a long term trend.

Extent of the Shortage

The Engineering Manpower Commission is deeply concerned over the magnitude of the shortage of engineers and scientists and its probable consequences to the national health, safety, and interest. Studies will continue to be made to determine to what extent the shortage is a short term or a long term problem and what efforts can be made to aid government, private enterprise, and others in determining policies to promote the most effective utilization of engineers and to maintain the supply, so that our technological superiority will not suffer.

The seriousness of the situation is aggravated by the fact that coupled with the existing shortage is the prospect of increasing shortage over at least the next four years. The output from our engineering colleges is fairly well fixed until 1954. The prospect as to numbers of graduates compared to foreseen demand is not encouraging.

Dean Hollister has told me that he expects to undertake at once revised estimates in accordance with the figures presented to you today. In making such an estimate of the needs of future years, it will of course be necessary to formulate some judgment as to the division of this 60,000 present estimate of unfilled need. How many of that number are needed temporarily to meet requirements of defense industry which will not repeat, and how many of that number represent a continuing requirement over coming years as a result of technological development in industry?

The Effect of the Shortage and the Steps to Counteract It

What is the effect of this shortage? The strength of the United Nations in the present world struggle depends upon industrial might. We can not match our enemies in numbers of men—we must excel them in the quality and quantity of weapons produced as well as in the spirit and resourcefulness of individual soldiers. If the United States is to be "The Arsenal of Democracy" we must have the necessary trained technical manpower, both in the Armed Services and in industry. To do this we must keep the pipeline full by steps to meet estimated needs for freshmen and graduates, as indicated on the slides previously shown you. Without student material our facilities for engineering education will suffer, to our great disadvantage.

To meet these problems the EMC of EJC was organized "To Aid in Establishing the Importance of the Engineering Profession to the National Economy, to Aid in Maintaining the Supply of Trained Engineers and to Promote the Most Effective Utilization of Engineers in the National Health, Safety and Interest."

How have we gone about this? The first step was to get wide publicity for the facts—or the best possible estimate of the facts—as to "The Critical Shortage of Engineers." Dean Hollister's article, titled as above, and various other articles on the same or similar subjects have brought about quite widespread realization of the seriousness of the situation. Action taken as to deferment of college students, though not pin-pointed so as to make it apply to the specific needs here discussed, indicates such realization. The pronouncements and charts of the U. S. Bureau of Labor Statistics have been changed so as to present to prospective students an entirely different picture as to the outlook for engineers.

The EMC published and distributed to principals, guidance teachers and science teachers in some 23,000 high schools a circular descriptive of the need and the opportunity for engineers, accompanied by other material relating to the importance of the engineering profession and the opportunities which it offers. We have urged upon the Department of Defense and upon civilian agencies of the government, steps to secure most effective utilization of engineers. Mr. Armsby of the Office of Education of the Federal Security Agency, as a member of EMC, has been very effective in this connection. The Civil Service Commission has taken steps to avoid misuse of engineering manpower. The Defense Department has not yet gone as far as it should in organizating its procedures to "Promote the Most Effective Utilization of Engineers."

The problem is a large one but it *must* be solved, as the most serious aspect of the shortage of engineers and scientists is its effect upon the production of munitions. One serious defect in the present situation is the almost universal tendency of the Armed Services to catalogue every Reservist *now* in the same rating which he had in the Service in Warld War II. If he was an artillery observer then he is so thought of now, even though meanwhile under the G. I. Bill or otherwise, he may have graduated in electrical engineering and have had considerable practical experience in some specialized field. Draftees seem, in many cases, to be assigned with little regard to civilian training and experience.

Without doubt this situation will improve. Steps are now underway to assure to defense industries more adequate opportunity to present their cases for deferment of individuals essential to defense production.

There is a lot of emotional feeling regarding the service of men under arms as compared to their service in defense industry, but we must be realistic and objective with regard to our point of view on that subject. It goes without saying, I believe, that we cannot possibly match our potential enemies in numbers of men. We must out-produce them. For that reason it is absolutely essential, as the previous speakers and others have pointed out and as you no doubt realize, that our manpower be utilized where it is most effective. In some cases that may even be contrary to the inner desire of the man himself; but somehow we must get across the idea that service in production and service under arms are equally important and honorable.

Industry, too, must avoid waste of technical manpower. The institution within industry of well-planned high level training courses for graduate engineers is urged by EMC as a means of securing the integration of these men into productive activity and their ability to make maximum contribution to the National effort. The reestablishment of Federally aided training courses for technicians is under consideration.

The Demand for Engineers

I would like to read from an advertisement which I clipped from a recent issue of a technical journal. This bears upon the general situation as to the need for engineers for both military and civilian objectives. I will omit the name of the company—just call it Blank Company. My only possible objection to this article is use of the words "Qualified" and "Experienced." Perhaps this organization should train its own men.

This is the advertisement as it appeared:

"THE OPEN DOOR

to career opportunities for QUALIFIED ENGINEERS *Career* opportunities for *experienced* ELECTRONIC, ELECTRICAL and MECHANICAL ENGINEERS — PHYSICISTS — METALLURGISTS — CHEMICAL and CERAMIC ENGINEERS are now open at ———, pioneer in many of the world's greatest developments in virtually every field of ——— (the company product).

The opportunities are in research, development, design and application, also in

technical sales—on commercial projects as well as the nation's defense program.

These are not temporary positions. Many of ———'s activities today are designed to satisfy the nation's military needs. ——— however, has always been (even in peacetime years) an arsenal from which the military forces have been equipped with the finest ——— apparatus.

——— also is working on many commercial long-range projects. They call for expanding research and development in a diversified line of products. These openings offer lifelong career opportunities. Unlike feast or famine businesses, ——— has forged ahead regardless of wars or depression.

At ———, you enjoy professional status, recognition for accomplishments . . . unexcelled research facilities for creative work . . . opportunities for advancement in position and income . . . pleasant surroundings in which to work. You and your families participate in Company-paid hospitalization, accident and life insurance. Modern retirement program. Good suburban or country residential and recreational conditions. Opportunities for graduate study.''

I read this to illustrate what opportunities the law of supply and demand is likely to bring forth for engineers in many companies in addition to those which already offer these advantages.

This and other similar advertisements, and a consideration of the new fields which science is opening up to industry lead to the belief that engineering activities are entering upon a vast expansion. Irrespective of the new fields, the increasing population of the country and the high birth rate promise high demand for the products of industry. Admitting that a portion of the present shortage is due to defense demands, there remains a great increasing requirement to meet production for civilian use. Should high production to meet defense needs continue, as seems quite likely, there will be continued demand for more advanced and improved designs to keep the United States always in the forefront as to quality of weapons.

Perhaps I may briefly summarize the whole situation, as we look at it, as follows:

Engineers are essential to the defense effort and to our industrial future.

Engineers are in short supply.

Engineers must be utilized to the maximum possible advantage.

The "Engineering pipeline" must be kept full. Adequate supply of this critical element of America's manpower is essential.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College Hanover, N.H.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	Carnegie Institute		E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5 or 12, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Capitol Radio Engineering Institute	Oct. 2, 1951	W. Oncken, Jr., Bureau of Ordnance
New England	University of Rhode Island	Oct. 13, 1951	W. C. White, Northeastern University
North Midwest	University of Wisconsin	Oct. 5 & 6, 1951	K. F. Wendt, University of Wisconsin
*Ohio	Ohio State University		W. F. Brown, University of Toledo
*Pacific Northwest	Seattle		T. H. Campbell, University of Washington
*Pacific Southwest	Los Angeles San Francisco	April, 1952	S. F. Duncan, University of Southern California
*Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952.	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Clarkson College	Oct. 5–6, 1951	W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

Present Status of the Problem of Scientific and Engineering Manpower*

By M. H. TRYTTEN

Director, Office of Scientific Personnel, National Academy of Sciences–National Research Council

This is perhaps a particularly appropriate time to review the status of the problem of the supply and utilization of scientific and engineering personnel. This is true because on the one hand the dimensions of the demands for such personnel for all of the various activities involved in the maintenance of our civilization and in national plans for mobilization are beginning to become clearer. It is also possible at this time to review some of the halting attempts to achieve national policy and to forecast the difficulties which lie ahead in solving this most difficult of all of our problems. And finally, it is possible to estimate a little more accurately than heretofore what may be happening to our pipeline of personnel in training.

The demand for engineers this summer is probably the greatest that has ever been known in our history. I need not go into details on this matter, since I believe my colleague, Colonel Brown, will indicate the results of a recent survey by the Engineers Joint Council. Your own experience has been sufficient so that I am sure you will not be unduly astonished at the results of this survey. Let me add merely in passing that the demand in many of the fields of science appears to be of the same order of magnitude in proportion to the personnel in those categories as is the case for engineers.

I need not stop to discuss the probable future supply in the field of engineering, since that situation, too, I believe, is familiar to you. You are aware of the progressively lowered enrollments in the various engineering undergraduate classes and also of the probable magnitude of the freshmen class this fall which, according to the latest information, seems to be likely to be less than the freshmen class of 1950. Here, too, I would only add that the phenomena which gave rise to these lowered enrollments seem to be equally effective in the fields of the sciences so that the graduating classes in the future will also progressively decrease in the sciences much as they are decreasing in the field of engineering.

I am sure you will agree with me that there is no phenomenon at the present time that has more serious implications for the future than this widening divergence between supply and demand for highly trained manpower. There is a very direct relationship between the productivity of any nation in its industrial output and its supply of scientific and engineering personnel. This can be expressed differently by stating that there is a very direct relationship between the standard of living of any country and its supply of scientists and engineers. This has been the basis of a recent thoughtful article appearing in *The American Scientist* the official organ of Sigma Xi, by Ewart Smith, (reference: Vol. 39, p. 274, April 1951). While this is important enough in itself, it is, of

* Given at General Session of American Society for Engineering Education, East Lansing, Michigan, June 28, 1951.

course, overshadowed at the present time by the direct relationship between the number of scientists and engineers in any country and its ability to produce in adequate quantity and to use the most effective military equipment possible in the light of the present development of science. And yet in spite of these close relationships, in spite of the direct dependence of both the national welfare and the national security on the supply of personnel in these categories, the phenomenon itself remains essentially unknown and unappreciated by the general rank and file of persons in the population. I believe it is fair to state that this phenomenon is not even well understood and well appreciated by great numbers of scientists and engineers themselves. I know this to be true because I have spoken to groups of both scientists and engineers about the situation and have always been astonished at the lack of awareness of the problem which is manifest in such a discussion.

Part of the reason for this lack of understanding is the relative recency of the problem, since prior to World War II no such problem was recognized. Part of the reason is that we have been unusually fortunate in that our educational institutions have developed rapidly and spontaneously in response to powerful social movements and without the necessity of Federal funds for any substantial part of their support. There has always been a keen appreciation of the importance of education among our population. Many of our colleges have been founded and maintained by wholly private groups to serve some social or religious end of their own. The public generally has been generous of its support to such institutions and has been willing to sanction the setting aside of substantial portions of local tax monies for the development of education. Usually the motivations behind these impulses have been a genuine interest and desire to see to it that the maximum of opportunity is available so that the young men and women of the nation might realize their potentialities. There was thus flowing from our schools and colleges over the past decades since the turn of the century an ever increasing supply of highly trained young people, which apparently up to World War II was reasonably well adjusted to the increasing needs of our civilization for such highly trained specialists. It is only since World War II and under the stress of a new emergency that the sharp increase in demand and the failing supply have become conspicuous. I would call attention to the fact, however, that throughout most of our history the focus of attention has been on providing educational opportunities for individuals to reach their own maximum potentialities, rather than on the products of the universities and colleges as an essential resource for the necessary activities of our civilization. It is only recently that the compelling importance of personnel with specialized training as an indispensable factor in the national welfare has tended to focus attention on the supply of persons emanating from the schools, rather than on the welfare of the individual. This is a major shift in interest and one which is going to require real effort if it is to be driven home into the consciousness of the average American. It must be understood if the public is to sanction the steps that must be taken to provide an adequate flow of specialized personnel. It will not be easy, because it substitutes an abstract idea for an emotion.

It may be well to mention here, too, that we have been exceedingly fortunate in that the development of higher education in the United States throughout the past five decades has been undisturbed, excepting for two short periods, by substantial interference arising from military activity. During this period most young men have found it possible to progress directly through the various stages of training without having to take out substantial periods of time for military training or service. The effect of this is probably not adequately under-

stood. I can recall, for example, that the development of radar during World War II was largely in the hands of specialists in electronics who had graduated from the engineering schools and physics departments. During the middle of World War II an analysis by the National Roster uncovered the fact that the average age of these young specialists was less than twenty-six. Most of them were, therefore, young men with a bachelor's degree plus one or two years of graduate study prior to their employment, or war work in electronics. I can quite well imagine that had these young men each been required to spend a year or more in military training or service many of them would not have achieved the level of experience which made their employment on these projects possible. Others again could possibly have been deflected from the area of training which they had entered upon, and finally, all of them would have been at least one year less advanced, which at that age is a considerable factor. It would seem to me highly reasonable to suggest that the ultra important radar developments in World War II would at least have been delayed and in many cases might not have succeeded had this been the case.

I should like to suggest that in thinking of the problem of scientific and engineering personnel at the present and the apparent increasing divergence between the supply and demand, that the matter be looked at against a larger background than has perhaps been the case in some presentations in the past. I know that it is customary to blame this divergence largely on a public attitude that the technical professions appeared for a short time to be threatened with overcrowding. While this may well have been an important factor, it seems to me that it is possibly not even the most important factor. It is true that engineering fall enrollments for the past year reduced to the point where actually a smaller percentage of the high school graduates of 1950 entered engineering than was the case prior to World War II. But there may be a number of factors which are important considerations in this connection. One of these is unquestionably the high employment opportunities with substantial salaries for personnel of moderate training. It is, of course, well known that union wages in a number of activities are sufficiently high to be attractive to many high school graduates. But there are other employment opportunities also that apparently offer important inducements. Many of these are activities which require only a reasonably short period of training, such as the many maintenance and services activities in the fields of automotive transport, home appliances of various kinds, including air conditioning, and others. In the fields of advanced training the number and variety of job openings appear to be steadily on the increase in our civilization. In the field of business, for example, there are increasing opportunities for persons with rather highly specialized training, because of the increasing complexity of modern business organizations and the precision with which they must operate. Each one of the larger corporations has a wide variety of positions in which they themselves have established reasonably long training programs or which require individuals with specialized training from universities and colleges. Because of these demands recruitment programs have increased and competition for personnel of high ability has increased.

Since the beginning of the century the population of the United States has only increased by approximately 60%. Yet in many fields the increase in personnel has been vastly greater. In most of the sciences and engineering the increases have been approximately 700%. In such academic fields as modern languages the percentage has actually been greater, up to about 800%. Even in the teaching profession school teachers as a whole have increased by nearly 300%. While there is this vertical rise in the increase in a number of specialities, there has occurred simultaneously a substantial

increase in the number of professions which require comparable long training. But all of these factors together are producing a greater and greater competition for that relatively small percentage of the population which is capable of taking and using advanced training. The factor which suddenly makes this dramatic is the imposition on the normal rate of development of technology in our civilization, a sudden and dramatic increase due to the present remobilization and to the demands produced by the international situation generally. It is not only in the sciences and engineering that there is a tremendous competition for personnel at the present time. Due to the suddenly increased activities of the Federal Government in all of its branches, there is unusual recruitment also for experts in the fields of management, of the social studies, and in other fields.

The increasing demand is, however, matched by what appears to be a decreasing proportion of individuals from the high schools who elect to enter the fields of science and engineering. While this may be due to the increasing opportunities in other fields, it seems probable that it may be affected also by other factors. One of these may be the effect of changing emphasis in education at the secondary level. There has been a steady mounting interest on training the high school population for the so-called activities of life and for citizenship. It is true that a large proportion of high school graduates do not go on beyond high school graduation. The increasing concern with the needs of this larger part of the high school population has inevitably been reflected in decreasing concern with the needs of those whose training has only begun and who must continue on through the college and the graduate school. Unquestionably this appears to be having its effect not only on the quality of the work done in the secondary school, but in the election of courses of study less likely to direct the interest of students into courses preparatory to science and engineering. Besides this there appears definitely to have been increasing difficulty in holding high school teachers or in recruiting new ones of substantial training in pre-science and pre-engineering courses. Not only have job opportunities lured high school graduates into employment directly, but they appear also to have lured away high school teachers. There is, unfortunately, inadequate quantitative information on which the validity of these remarks can be tested or the magnitude of the phenomenon discussed, but if present indications are true it is a problem of utmost importance and worthy of attention.

To meet the present situation it will be necessary to break completely new ground. The present role of the highly trained specialist is so fundamental to our national welfare and our national security that the problem becomes one in which a national point of view must enter. It is also true that there must be a recognition that the training and utilization of personnel for the many activities which require advanced training is just as important and must receive just as much attention and recognition as the training and utilization of combat forces. This point of view is not adequately reflected as yet in national policy nor in national programs. Our whole concept of manpower policy is as yet inadequate to the special circumstances of the present. The experiences of the past have been largely inapplicable to meet the present situation and yet the shadow of the past hangs heavy over any attempts to achieve policies realistic under present circumstances. Selective Service policy in the past, for example, was conditioned by the special circumstances of World War II. The habit at that time was to make the decision as to whether an individual were to remain in his employment or enter the military service based upon the concept of essentiality to the national effort of the time. With all its uncertainties, nevertheless it provided a philosophic basis for an individual decision which could at least theoretically be considered an adequate criterion. It, of course, did not reflect in any way the fact that even after a war the activities

of the nation must go on and other emergencies must be provided for. Under present circumstances this philosophic basis is obviously quite inadequate. The present situation is one in which the emphasis should be much more largely on long-time preparation for the necessities of an uncertain future than for the requirements of the present.

Some attempt has been made to reflect this new point of view in the Selective Service regulations established by the President to cover the deferment of students. You are, of course, familiar with the details of this plan. The plan is now in operation and much of the testing, which is a conspicuous feature of the plan, has actually occurred. Approximately ⅔ of the students who have applied for tests have been tested and the third and fourth contingents will very shortly take their tests. The program at the present time appears to be working as smoothly as can be expected. The tests, themselves, have met general approval on the part of the students and the public press. The attitude towards the program on the whole has been steadily shifting to a greater degree of approval on the part of the general public. The Gallup Poll on May 26 published the results of a nation-wide survey of public opinion on the deferment program and announced that on the whole the general public approved the plan. Fifty-five per cent of those interviewed expressed approval; 36% expressed disapproval and 9% were undecided. Curiously enough, when those interviewed were broken down into categories in terms of their training, it was found that those with only grade school training approved the program in the ratio of 58–32, almost two to one, while those with college training approved the program in a ratio of 56–37, a ratio of about three to two; those who were listed in "Who's Who" endorsed the program in the ratio of better than 2–1 or about 66–31.

The attitude of draft boards and the State Directors of Selective Service appears to have improved substantially and there is now a general feeling of confidence in the National Headquarters of Selective Service that there will be no great difficulty in the administration of the program.

There remains, however, still a problem with regard to the deferment of persons whose training has been completed. There is less desire on the part of draft boards to defer, what appears to them to be indefinitely, a young man with advanced training, even in spite of the fact that he may be in a category in serious short supply and of considerable importance to the mobilization effort. Similarly, the problem of Reservists has not yet been adequately met. Decisions on requests for deferment on the part of Reservists called back to active duty are as yet achieved by procedures developed some time ago and reflect essentially the military need for these individuals much more than they do civilian requirements.

Underlying both of these problems is a dangerous assumption. The difficulty of retaining specialized personnel in a civilian activity is to a large extent due to the assumption that the individual will be called in for a relatively short period of service and then returned. The length of service required of draftees is twenty-four months and for Reservists with military service in the last war requests for discharge may be made after seventeen months. However, it should be noted that in the present world situation there can be very little guarantee that this length of service will be all that is required. In actuality, any substantial increase in hostilities within the next twelve months requiring increased mobilization will undoubtedly present a military situation which will be completely overriding in the disposition of individuals in the Armed Services, for it will be impossible under such circumstances to withdraw individuals actively built into positions of importance in the military service on the basis of a civilian specialty. National policy is still a far cry from reflecting a realistic understanding that national security is grounded solidly on more than one pillar of support, the military arm, but rests also on at least one

other pillar, a vital, versatile, and vibrant technology.

It has long been apparent that if national policy is to achieve a sound basis in realistic understanding of the problem of training and utilization of scientific and engineering manpower, then there must be some one central place in the Government where such matters are focused. This led to the recommendation to the National Security Resources Board by the Engineering Manpower Commission of the Engineers Joint Council and by the National Academy of Sciences and other groups that a national scientific personnel board be provided for in the new Selective Service Act. The Congress did not see fit to consider this recommendation when it was submitted to them through the Thomas Committee of the NSRB. Nevertheless the concept of a central policy committee to deal with such matters was not entirely lost.

Perhaps the most important development up to the present is the establishment within the Office of Defense Mobilization of a Committee on Specialized Personnel, appointed by the Director, Mr. Charles E. Wilson. This Committee will have responsibility for reviewing and initiating policy recommendations in the whole field of specialized manpower, including Selective Service, the problem of Reservists and of Civil Service employees. The Committee will also inquire into the implementation of policies by the Government. The Committee is composed of persons within the Government and non-Government personnel in approximately equal ratio. Some of the members from within the Government are the Director of the Science Foundation, Director of the National Advisory Committee for Aeronautics, Chairman of the Research and Development Board, Director of the Defense Manpower Administration, and the Commissioner of Education. The non-Government members have been selected from the fields of the sciences and engineering and include a representative of the social sciences in the person of Dr. Douglas Brown, Vice-President of Princeton University. The two members of the Engineering Manpower Commission are Messrs. Harry W. Winne of General Electric and Dean S. C. Hollister of Cornell University. Besides this Committee, there are now permanently established Advisory Committees within the Selective Service System for dealing with matters which are peculiar to that agency. These groups are important in that they furnish for the first time official bodies at policy levels where matters relating to these important issues can be centered for policy discussions.

However, in this problem it should be emphasized that the major difficulty is that of public awareness of the magnitude and importance of the problem. For this reason it is extraordinarily important that an organization such as the Engineering Manpower Commission be in existence. The EMC has a challenge and a function made even more important by the existence of such agencies as I have described in the Federal Government. They can furnish a channel through which information can be brought to those responsible for policy. They can take a leading part in the important function of disseminating information for the education of the lay public, for the information of employers and for the guidance of training institutions. They can present to the public, to the Congress and to the Federal Administration considered opinions of the engineering personnel of the nation for the guidance in dealing with policy matters. If I may make any statement in conclusion, therefore, it is to urge that every effort be made to strengthen the hands of such an organization as the EMC in order that it may play to the full its key role in assisting to secure an alleviation of the present crisis condition, in working for an augmented flow of persons in training, better support for engineering education and better utilization in the national interest of the personnel already trained and on the job.

National Science Foundation Developments*

By A. A. POTTER

Dean of Engineering, Purdue University Member; National Science Foundation Board

Basic Research a Foundation for Invention

America's present industrial supremacy may be traced largely to the fact that this country has had a type of government which has encouraged its people to invent, to translate their inventions into marketable products, and to manufacture such products in quantity and at a cost to stimulate and satisfy public demand. The welfare of our country in the future, even more so than in the past, will depend upon its scientific and technological developments and these, in turn, will require people who have ability to create basic scientific knowledge.

In the past, our inventors were fortunate to be able to draw upon the basic science findings of other countries, mainly Europe. Unfortunately, two world wars have greatly depleted the human and material resources of other lands, so that for many years in the future, the U.S.A. has the responsibility for building up a stock pile of basic scientific knowledge. Our great asset as a nation has been our ability to convert scientific knowledge in practical utility. Basic research, on a scale commensurate with the dominant position of the U.S.A. in applied research and invention, is essential to protect the industrial and technological competence of our people. Unless we lay the foundation of basic research for the practical discoveries and inventions, we shall fall short in the future as a creative people.

E. V. Murphree, President and Director of the Standard Oil Development Company, in the *American Scientist* for April 1951, states:

"Our health, our industry, our agriculture, and our weapons for national defense are all based on the application of scientific knowledge. This scientific knowledge has been slowly built up through the years by basic research. Without the foundation laid by basic research, the remarkable advances in our standard of living and the nation's health, which have occurred steadily through the years, would have been impossible. It is clear therefore that the proper support of basic research is fundamental to our progress and to our survival as a nation."

Dr. Murphree also calls attention to the fact that "Penicillin is the product of basic research" and that "one of the strongest reasons why Soviet Russia has not overrun Europe is our greatly superior position on atomic bombs—the most spectacular creation of basic research."

National Science Foundation Endorsed by Leaders

For a number of years, there has been a nation-wide demand for the creation of a National Science Foundation and its importance has been recognized by official statements by the President, the only living Past President, Herbert Hoover, in the hearings, conferences, and debates of several Congresses, and in writings and statements of outstanding scientists, engineers, physicians, military leaders, educators, and industrialists.

While opposing government control of

* Paper presented at the 59th Annual Meeting of The American Society for Engineering Education at East Lansing, Michigan, June 26, 1951.

education and research, the leaders in science and engineering recognize the following successful precedents for the establishment of a federal agency for the support of advanced education and research in the sciences:

(1) The Morrill Act of 1862 and the later Morrill-Nelson Acts under which the nation-wide system of Land-Grant colleges and universities was established.

No harmful effects on the national system of education or on the Land-Grant institutions themselves have resulted from the support derived from Federal grants under the acts, but those colleges have contributed richly to American agriculture and industry.

(2) The Hatch Act of 1887, establishing the Agricultural Experiment Stations of the country, and the subsequent Adams Act, Purnell Act, Bankhead-Jones Act, and the Research and Marketing Act amending the Bankhead-Jones Act, providing Federal aid for agricultural research, have been of the greatest benefit to the nation at large and particularly to its farm population.

(3) The Act establishing the National Bureau of Standards, a division of the Department of Commerce, has resulted in better standards of value to the public.

(4) The Act establishing the National Advisory Committee for Aeronautics, an independent Federally-supported agency having as its purpose the development, through research and experimentation, of improved methods of air transportation. It is widely agreed that NACA has rendered service of the utmost importance to the science of aviation.

Thus, in the fields of higher education, agriculture, maintenance of standards, and the specialized field of development of aeronautics, support given by the Federal Government to research has been of very great importance without causing injury to private business or the domination of industry. It has long been recognized that similar aid rendered on a broad basis and safeguarded as in the present National Science Foundation Act would be of similar benefit in the fields of basic science.

We have reached a stage of such complexity in scientific endeavor and cost of equipment necessary for basic research is so great that universities and private research foundations have insufficient resources to go forward speedily in creating new knowledge. Thus government aid for basic research is essential. In so far as industry is concerned, there is a limit as to the amount it can expand for long range basic research projects. Many American industries are well equipped to invent and carry on programs of basic as well as of applied research, but few have the means for basic research which has a remote connection with immediate gains.

Objectives of National Science Foundation

In the National Science Foundation Act of 1950 (Public Law 507, 81st Congress, S247) the Foundation is established in the executive branch of the Government as an independent agency. The Foundation is authorized and directed, among other functions, to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences; to award scholarships and graduate fellowships in the above fields; to foster the interchange of scientific information among scientists in this and in other countries; to maintain a register of scientific and technical personnel; and to initiate at the request of the Secretary of Defense research projects in the interest of national defense.

The primary responsibility of the Foundation is to develop a sound national policy for the promotion of basic research and education in the sciences. This will require the best thinking of the most competent of our people. To supplement the Board and the Staff, the

Foundation is authorized to establish special commissions to make comprehensive surveys of research, both public and private, recommending to the Foundation an over-all research program in the field of the survey. It is hoped that several such commissions will be functioning during the next year. It is expected that the thinking of organized scientific groups, including professional societies, will also be utilized in developing a national science policy.

The next most important task of the Foundation is to evaluate through factual surveys the need for research in the several basic scientific fields, with special reference to our national interest, and to provide emergency support in the directions of greatest need.

The Act authorizes and directs the Foundation to award "scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences." No decision has been reached about the support of undergraduate scholarships, but this problem is being studied by a committee of the board. There is, however, a most urgent need for graduate fellowships, as large numbers of our superior and potentially creative young people stop with the Bachelor's degree because of inadequate financial support. It is estimated that in the three-year period, 1947 to 1950, over 14,000 potential candidates for the Ph.D. degree in the sciences were prevented from entering graduate schools because of the lack of funds. In the immediate future, this problem will become more serious, as approximately one-half of the graduate students in the years, 1948–50, received G. I. benefits. The Foundation hopes that appropriations by the Congress will make it possible to provide about 2000 pre-doctoral and at least 100 post-doctoral fellowships during the fiscal year, 1952–53. These will make up only about 3.6 per cent of the graduate students in the fields of science, engineering, and medicine. The National Research Council, because of its 30 years of successful experience in fellowship programs, will administer the Foundation's fellowship program in the opening year, but appointments, as required by law, will be made by the Foundation. It is felt that the graduate fellowship program should be given preference by the Foundation to undergraduate scholarships at this time in order to insure an adequate supply of man power with the necessary tools for research in the basic sciences. Especially the post-doctoral fellowships should develop the future leaders in research and education as mature scientists, who have already received their doctorate, will thus be able to spend one or two additional years on specific problems in scientific research.

Starting Date for Fellowships Has Not Been Determined

Serious problems exist in the dissemination of scientific information, both internally in this country and in obtaining for our scientists the benefit of scientific information developed in other countries. The foundation hopes to be able to aid in the exchange of information in the following ways:

The staff of the Foundation expect to undertake a study to determine in which areas publication facilities are lacking or inadequate, where gaps exist in the major collections of scientific literature and how those gaps can be closed, and factors which contribute to a lag in publication of research results. The Foundation also expects to sponsor research to develop new techniques for the quick and economical dissemination of scientific information. The Foundation hopes that its means will make possible more travel by American scientists to scientific meetings in other lands in order to broaden their contacts.

In formulating a national policy for science and in planning for mobilization of scientific effort in case of a national emergency, comprehensive information about man power is essential. The national roster of scientific personnel was established at the beginning of the Sec-

ond World War to supply this information and has demonstrated its usefulness. In 1949, the National Securities Board concluded that the establishment of the roster on a broad basis was essential to our mobilization readiness. Pending the passage of the National Science Foundation Act, the U. S. Office of Education activated and administered the National Scientific Register in a most effective manner. It is expected that the National Science Foundation will assume direct operation of this Register some time during the fiscal year, 1951–52. It is expected that the Register will not only continue the registration of scientists and the analysis of their experience, but will prepare and publish statistical studies of the personnel included in the Register, and will develop and maintain a clearinghouse of information on scientific personnel.

As soon as the Congress makes appropriations for the fiscal year 1951–52 the Foundation will be ready to receive proposals for basic research.

While the Foundation hopes to concentrate its efforts on basic research, it is ready to cooperate, at the request of the Secretary of Defense, on other types of research in the interest of national security.

The National Science Board

The Foundation is directed to have a National Science Board of 24 members appointed by the President, by and with the advice and consent of the Senate. The Board is expected to be representative of the fields of basic science, medical science, engineering, agriculture, education, and public affairs, and is expected "to provide representation of the views of scientific leaders in all areas of the Nation."

The Board of the National Science Foundation has held six meetings up to date. It elected James B. Conant, of Harvard University, as Chairman of the Board and D. T. Bronk, of Johns Hopkins University, as Chairman of its Executive Committee. Acting upon the nomination and advice of the Board, the President of the United States of America appointed Alan T. Waterman, of O. N. R., as the first Director of the Foundation.

The Board set up the following divisions:

1. Division of Medical Research.
2. Division of Mathematical, Physical, and Engineering Sciences.
3. Division of Biological Science.
4. Division of Scientific Personnel and Education, which is to concern itself with graduate fellowships in the mathematical, physical, medical, biological, and engineering sciences.

The Director of the Foundation was requested to contact the major societies for nominations to membership in the several divisions, as the Board is to concern itself largely with policies and not with operation.

The Engineers Joint Council, at its meeting in New York on May 18, 1951, took the following actions with relation to the National Science Foundation:

Mr. Davies read a letter from Dr. Alan T. Waterman, Director of the National Science Foundation, dated April 23, 1951, asking for suggestions of names of engineers suitable for appointment as members of the Divisional Committee of Mathematical, Physical and Engineering Sciences of the Foundation. After discussion, it was VOTED:

> that the Secretary of EJC request each constituent society to report promptly names of three members suitable for appointment by the Director of the National Science Foundation to this Committee.

The members of the Committee on Engineering Sciences were asked to aid the secretaries in choosing names of appropriate engineers.

After further discussion on the work of the Foundation, and manner in which its funds were appropriated; the need for

properly trained personnel, etc., it was VOTED:

> that the Committee on Engineering Sciences, in consultation with the Committee of Secretaries, compose a letter to be sent by the Secretary of EJC to Dr. Waterman of the National Science Foundation, along the following lines:
>
> (a) that EJC took an active part in promoting the establishment of the National Science Foundation; (b) that EJC is vitally interested in the activities of the National Science Foundation; (c) that present EJC interest is indicated through the appointment some months ago of a special Committee on Engineering Science; the specfic purpose of which is to cooperate with the National Science Foundation in matters of basic research and education in engineering science; (d) that this Committee is composed of two members of each of the five constituent engineering societies of EJC. The Chairman of the Committee is Dr. Boris A. Bakhmeteff (ASCE). Its other members are Dean Thorndike Saville, ASCE; Dr. A. M. Gaudin, Dr. R. M. Brick, AIME; Professor A. G. Christie, Dean A. A. Potter, ASME; F. M. Farmer, M. J. Kelly, AIEE; Earl T. Stevenson, Dr. Chas. M. A. Stine, AIChE; (e) that Engineers Joint Council expresses the hope that there will be established a close relationship with this Committee to the end that the engineering profession may assist to the maximum in furthering the objectives of the National Science Foundation, and (f) that communications to the Committee may be addressed to the Secretary of EJC, or directly to the Committee Chairman, Dean Thorndike Saville, New York University, New York 53, N. Y.

Basis Research in Engineering

Some people are of the opinion that basic research is confined largely to mathematics, physics, chemistry and biology. Actually, many of the problems now confronting industry and the engineering profession cannot be solved without new basic engineering knowledge. As concrete illustrations:

We need more knowledge on contact catalysis and on the kinetics of steam-carbon and carbon dioxide-carbon reactions. Contact analysis is of vital importance in the conversion of coal to liquid fuels and it is also of potential importance in coal gasification.

We need to know more about the mechanism of combustion and coal structure. There are certain sciences basic to engineering which are no longer of interest to physicists and chemists, such as fluid mechanics, elasticity and plasticity, heat transfer, and electronics.

The Director as the Key Person

Finally, the effectiveness of the National Science Foundation will depend upon the Director, who is the key person in any research organization. The Science Board, made up as it is of very busy people, can concern itself only with major policy matters. The Director must have the breadth, vision, and wisdom to plan, approve, supervise, coordinate, and evaluate research programs at the cooperating laboratories; must interpret the findings of these laboratories so that they are comprehended by the public; and must have ability to command the confidence of the White House, Congress, cooperating organizations, National Science Board, and of the public at large. We are fortunate in having Dr. Alan T. Waterman as the first Director of the Foundation. He, as well as the National Science Board, however, will need the active cooperation and advice of engineers in insuring that basic research in engineering is carried out on a scale commensurate with its importance to American industry and security.

An All Powerful Engineering Organization is Needed

By T. H. EVANS

Dean of Engineering, Colorado A. & M. College

As most engineers now know, there was formed almost two years ago by EJC a committee to explore the desirability of establishing some means of increasing the unity of the profession. The committee was to be composed of 16 of the leading engineering technical and professional societies in the country, and is known as the Exploratory Group. Recently this Group has come out with four plans that are recommended for consideration as possible vehicles by which to achieve such unity. The plans are designated Plans A, B, C, and D. Plan A is essentially an expanded EJC with still a severe limitation on membership. At the other extreme is Plan D which is nothing more than the present National Society of Professional Engineers. B and C are compromises on A and D respectively. While the initiation of this vital move on the part of EJC is to be highly commended, there is no assurance that the profession as a whole will accept either of the plans as they now stand.

The following views about unity in general, and certain of the plans in particular, are not only those of the author but also of numerous acquaintances in the profession. Most of us have been hoping for many years for a chance to do something to unify the profession and for a chance to express ourselves on the matter. The move by EJC has provided that opportunity. The profession missed the boat by not unifying during its early development instead of permitting *only* autonomous technical societies to build into small but powerful organizations. We will now have to do in reverse the logical procedure that was followed by the American Medical Association in achieving outstanding professional strength first. It is hoped we will not miss the boat again while there is an unusual opportunity to unify. If all selfish interests to preserve certain relatively minor rights and powers can be forgotten in light of the bigger needs of the profession as a whole, then we can gain real unity.

Aside from any comments regarding the specific unity organizations proposed, it is believed we must first establish an objective. To a great many engineers the primary justification for unity in our profession is to achieve adequate economic and professional recognition of the character already gained by the powerful Medical profession. Such an objective is vital if we choose to establish Engineering as a real profession. It is hard to believe we will ever do it unless we have an organization that can include *all qualified engineers*. If such an organization is established we should have a potential even more powerful than the AMA because of the greater numbers involved. Whether we like it or not, it takes power through numbers to gain proper recognition, legislation, and action in these times. While most of us would condemn the lack of ethics, lack of public interest, the ruthlessness, and violence practised by the labor unions, we still must recognize their strength and power, which was gained through numbers. If we wish to achieve higher eco-

nomic and professional goals (and I believe most of us do) we must do it through an organization that has real power, as well as represents the Engineering profession. If true unity is not gained now there is a good possibility that a number of strong engineering collective bargaining groups, which are growing and consolidating, will provide what a lot of engineers feel is all they need. It is astounding to learn just how strong some of these organizations are, and they are expanding rapidly.

There seems to be an undercurrent in the Report of the Exploratory Group that any Unity organization is supposed to be subservient to the technical societies and National Society of Professional Engineers. If this is the intent of each of the four plans proposed then it appears to many to be entirely contrary to the needs of our profession. Many of us believe the unity organization should be THE Society and all others secondary to it. It is true we can never do without the technical societies as far as technical development goes, but what is the use of achieving technical supremacy if bricklayers, plumbers, rolling mill foremen, etc., through their unions, steal the ball and gain more from it than do those who create the improvements? In studying the four plans thus far proposed, it appears there is an attempt to preserve existing power within presently autonomous organizations and lack of recognition of the primary need, which is *one all-powerful group* to represent the Engineering profession. Why shouldn't existing groups that have the interest of the profession at heart merely lend themselves to helping their members and other qualified engineers to achieve a real unity organization? If gaining true unity in the profession means shifting the technical societies to a relatively subordinate position, many of us who are loyal and devoted technical society members can see no harm done. It is understood the Medical profession operates in such a fashion and we have a long way to go to equal them. The technical worth of the present societies would not be diminished at all.

To get down to specific plans proposed by the Exploratory Group it appears that Plan C comes closest to the objectives expressed above but it would need some major alteration in the plan of management and membership. It is not believed the technical societies should be predominant in the governing body, except through their members as "individual members" of the unity organization. Each individual member should have his one vote in determining directly the management and policies of the Unity organization.

One state branch of a national founder society has appointed a committee to study the four plans proposed, as well as the matter of unity in general. This committee has made a recommendation that contains five points substantially in accord with the above views. It is hoped that with real awakening of a grass roots interest in this vital matter something significant and useful will result.

Engineering educators can play an extremely vital role in stressing the need for real unity in this grand profession of ours.

Heat Transfer and Liquid Metals in Nuclear Reactors*

By RICHARD N. LYON

Principal Development Engineer, Oak Ridge National Laboratory

The rate at which heat can be removed from a nuclear reactor determines the rate at which the nuclear chain reaction can safely be operated. Heat arises largely from slowing the fission-product atoms. Two of these heavy atoms result from each fission, and they fly apart with a total energy of more than 150 million electron volts. The range of these atoms in solid matter is such that the heat is generated within the reactor fuel itself.

One problem, then, is the movement of heat out to the surface of the fuel. For simple geometries, the design is not difficult, but distortion of the heat flow pattern outside the fuel is reflected in distortion of the heat flow pattern within the fuel.

Protection is often required for the fuel material by a jacket or coolant conduit. The contact between the jacket and the fuel is of great importance. Not only can this be a source of serious thermal resistance, but also nonuniform contact can cause thermal stresses and distortion of the fuel element. It may also give rise to over-heated regions on the jacket.

Conduction through the jacket offers no serious complication unless fins or spacers are provided. Because of the high heat fluxes involved, even thin scale deposits are to be avoided, and a noticeable resistance may even occur in some cases where the coolant does not wet the jacket.

Proposed reactor coolants range in density from hydrogen to molten lead. Among other properties, coolants should possess the following to a greater or lesser extent:

1. Low neutron absorption.
2. Low corrosion rate with suitable jacket and conduit materials.
3. High thermal conductivity.
4. High heat capacity.
5. Large useful range of temperature.
6. Good chemical stability in nuclear radiation.
7. Simple pumping and plumbing requirements.

Liquid metals have been proposed as meeting most of these requirements. Some of them have low neutron absorption, they can be contained in usable conduit materials and they are are not subject to chemical decomposition.

Their useful range of temperature is larger than with any other liquids, and the thermal conductivities of liquid metals are higher than those of any other fluids.

The high conductivities of liquid metals have led to a difficulty in predicting the thermal resistance between the fuel jacket and the bulk of the coolant. Where the conductivity is high, its effect extends well into the turbulent region of flow and standard equations for the heat transfer coefficient cannot be used with assurance. Professor Drew and S. A. Isokoff at Columbia and Brookhaven have recently demonstrated the first point by measur-

* Presented before the Middle-Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

ing the temperature distribution across a turbulently flowing mercury stream in a heated tube. Martinelli was the first to predict the fact that the usual relationships could not be applied. At Oak Ridge National Laboratory the approximate equation $Nu = 7 + .025\ Pe^{.8}$ was proposed and its applicability has been demonstrated by several investigators.

Not all liquid metal heat transfer coefficients have been predicted by the above equation, however. Mercury, lead, and lead-bismuth alloy frequently fail to give as high coefficients in experiments. It has been suggested that this is due to poor contact between the liquid and the wall caused by non-wetting. Under this condition, the liquid is supported on the peaks of the wall roughness, and a region only partly filled with metal results. Further work is needed to prove or disprove this theory.

Plumbing problems with liquid metals are no more severe than the problem of handling radioactive liquids. In both cases, leaks are to be avoided. At moderate temperatures, small leaks in nonradioactive liquid metal systems cause only minor difficulties. At high pressures and elevated temperatures small leaks may become eroded into large leaks. Liquid metal systems have been operated at temperatures over 1600° F. without mishap.

The electrical conductivity of liquid metals can be used in pumping and metering. A variety of "electromagnetic" pumps and flowmeters have been developed and used with considerable success.

To stimulate research and use of liquid metals outside the atomic energy project, a Liquid-Metals Handbook was published last summer. Since that time 2500 copies have been sold and the book is now out of print. A second edition is being drawn up and will be available next fall.

College Notes

R. Norris Shreve, head of the School of Chemical and Metallurgical Engineering at **Purdue University**, will retire at his request from headship of the school to devote his time to teaching, research and writing. He will be succeeded by Edward W. Comings, professor of chemical engineering at the University of Illinois. Announcement of the change was made by Dean A. A. Potter, of all the Schools of Engineering at Purdue.

Ivan C. Crawford, dean of the College of Engineering of the University of Michigan, will join the **University of Denver's College of Engineering** faculty at the end of the current academic year. Dean Crawford has served as dean of Engineering at three major institutions—University of Idaho, University of Kansas and University of Michigan.

Gifts of $1,175,000 toward a Materials Testing and Processing Laboratory under construction at **Cornell University** were announced.

Completion of the units in early 1953 will enable the engineering college to undertake new defense research, according to S. C. Hollister, Dean of the College.

Properties and Requirements of Materials in Nuclear Engineering*

By DAVID H. GURINSKY

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The selection of materials is dictated by the conditions of service to which the material will be subjected. This is the basis for selection in the field of atomic energy as in other fields. Most of the same criteria apply in this new field, such as yield strength, tensile strength, creep strength, corrosion resistance, etc. However, as in any specialized field, certain properties assume greater significance. If one has to select the one property which is novel and important to the field of atomic energy, it is the cross section. If the element, or alloy, is to be used in a reactor, its cross section must be known. If the cross section is too large, it cannot be used, since the neutron economy may be upset.

The absorption cross section for neutrons is defined as the area of the nucleus for absorption. The microscopic cross section has the dimensions cm^2 and is given in barns. One barn is defined as 10^{-24} cm^2. The engineer is actually more interested in the macroscopic cross section, which is the product of absorption cross section σ_a and number of atoms per cubic centimeter (N).

In the field of aeronautics, materials are compared on their strengths per unit weight. Likewise, one may arrive at a figure of merit for materials which may be used in a reactor. To obtain a comparison of materials, one selects the property of interest and divides it by the macroscopic cross section. By way of illustration, the following elements and alloys have been arranged according to their decreasing merit, with yield strength as the property of interest (Table I). The yield strength selected was that obtained on annealed material. Some of these materials are not ordinarily used in the annealed condition. It can be seen that if the yield strength of a steel could be increased by a factor of 5 and this is possible then the quality factor would be 0.8. Only in this condition does steel start to compare favorably with annealed magnesium and zirconium. It is still not as desirable as Be on this basis.

There are, however, other quality factors which need to be computed such as the creep strength at elevated temperature. In this case, the order will probably be different. At high temperatures the stainless steel because of excellent creep resistunce should show up favorably even though the cross section is high. It becomes apparent then that the conditions of service will, even in

TABLE I

	Yield Strength $lb/in^2 \times 10^3$	σ_a cm^2 10^{-24}	F.M. $\times 10^6$
Be	26.	.009	23.6
Mg	14.	.4	0.88
Zr	15.	.5	0.71
Al	5.	.23	0.42
St. Steel	40.	2.8	0.19
L. C. Steel	30.	2.6	0.16

* Presented before the Middle Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

atomic application, be a determining factor in the selection of materials.

Radiation Properties

Thus far, we have considered one new physical property of materials (namely the cross section) as a basis for selection. There is an environmental aspect which is also new and has a real bearing on the kind of material which is recommended for a particular use. One must ask, will this material be stable to "Radiation"? Although there are four basic types of particles or radiation, fission products, neutrons, Beta and Photons, present in a reactor, only the first two are of importance to metals and alloys.

I shall discuss in general terms only the effect of neutrons. If a fast neutron strikes a nucleus of a metal it has sufficient energy to knock the struck atom out of its position in the lattice. The energy of the struck atom is given by

$$\Delta E = E_0 \frac{2A}{(A+1)^2}$$

where E_0 = initial energy of the neutron,
ΔE = loss of energy of the neutron or energy picked up by the struck atom,
A = atomic weight of struck atom.

The original neutron can go on to strike more atoms in the lattice. Likewise the struck atom can go to knock more atoms out of their lattice positions or it may lose its energy by ionization. The damage to a lattice is then computed by determining the number of atoms which have been displaced. Dr. Slater[1] in a recent article in the *Journal of Applied Physics* has pointed out another approach to radiation damage which is statistical or thermodynamic. The argument in this type of analysis is as follows: The energy required to displace an atom from its lattice site is of the order to 25 ev.

TABLE II

RESISTIVITY* OF Cu_3Au SAMPLES BEFORE AND AFTER IRRADIATIONS

Neutron Flux†	Ordered Samples		Disordered Samples	
	Before	After	Before	After
0.4	4.60	5.71	11.20	11.25
0.6	4.60	6.25	11.20	11.25
1.0	4.60	7.54	11.20	11.17
1.5	4.60	8.36	11.20	11.21
3.3	4.60	10.10	11.20	11.30

* Unit of resistivity: 10^{-6} ohm-cm.
† nvt above 50,000 ev. Unit is 10^{19} n per sq. cm.

If initial energy of the neutron is dissipated amongst the atoms along its path in 25 volt increments, we will have for a 1 mev neutrons approximately 4×10^4 atoms which have been brought to the vaporization temperature. Since this high temperature region is highly localized, these regions which have been so heated quickly cool down and are quenched. Many of the atoms will not have a chance to return to their original positions. The net result is a region in the metal or alloy where many atoms have been displaced. This gives rise to a stress in the lattice. This is equivalent to work hardening.

To illustrate this effect, the published work of Billington and Siegel[2] may be cited. They selected an alloy of copper and gold for this irradiation study. The ratio of atoms of copper to gold is three to one. This alloy Cu_3Au may by proper heat treatment be obtained in the ordered condition. In this condition the atoms of gold occupy the corners of a cube and the atoms of copper occupy the center of the faces of the cube. Also by another heat treatment, the alloy may be obtained in the disordered condition, or stated differently, the atoms of gold and copper take up random

[1] "Effects of Radiation on Materials," J. C. Slater, *J. A. Physics*, Vol. 22 (237–251), March, 1951.

[2] "Effect of Nuclear Radiation on Metal," D. S. Billington and Sidney Siegel, *Metal Progress*, Dec.; 1950, pp. 847–852

positions. The properties of this alloy differ markedly depending on whether the alloy is in the ordered or disordered condition.

Samples of the ordered and disordered alloys were subjected to different total irradiations. By consulting Table II, it can be seen that after an irradiation dosage of 3.3×10^{19} neutrons the ordered alloy has been almost entirely converted to the disordered form. This is striking proof of the fact that atoms are displaced from their lattice positions. Of the two methods considered for calculating the damage, the second method seems to explain the results of this experiment.

These experimenters have tested the effect of radiation on many materials by measuring the electrical resistivity and hardness changes. They found that if the material was subjected to sufficient radiation, hardness increases were observed. Aluminum seemed to be an exception. The greatest increases in hardness were observed if the original material was in the softest condition. A saturation effect was noted for beryllium copper alloys and various stainless steels.

In conclusion, if one wishes to generalize on the materials problems in the field of atomic energy, it can be stated that there is one new physical property, the absorption cross section, and one new environmental condition, radiation, which must be considered by the materials engineer in the selection of materials.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS

ANNUAL MEETING AND EXHIBITION

BELLEVUE-STRATFORD HOTEL – Philadelphia, Pennsylvania

Meeting—Wednesday, Thursday, Friday, November 28, 29, 30, 1951
Exhibition—Wednesday & Thursday, November 28 & 29, 1951

The central theme of the entire meeting will be
EDUCATION & TRAINING for EXPERIMENTAL STRESS ANALYSIS

Technical sessions will be devoted to—techniques—applications and models—fatigue testing—stresses in the plastic range—vibration and impact—in addition, there will be a symposium on the topic of education and training for experimental stress analysis.

All A.S.E.E. members, and their friends, are invited to visit the exhibits and to attend the technical sessions. (Attendance at the exhibits will be free of charge. For any or all of the technical sessions the usual registration fee of $3.00 will prevail).

A.S.E.E. members, or friends, wishing to show apparatus or equipment should communicate directly with Mr. Greer Ellis, Chairman, S.E.S.A. Exhibits Committee, P. O. Box 77, Pelham 65, N. Y.

Inquiries relating directly to the meeting should be addressed to Mr. Bruce L. Sutton, Co-Chairman, S.E.S.A. Meetings Committee, c/o Baldwin-Lima-Hamilton Corporation, Philadelphia, 42, Pa.

The S.E.S.A. will be glad to send you a program if you will direct your request to either of the above, or, to the Society for Experimental Stress Analysis, P. O. Box 168, Cambridge 39, Mass.

Technical Information Services at Atomic Energy Laboratories*

By D. PULESTON

Brookhaven National Laboratory, Upton, New York

The following description of the technical information services provided at Brookhaven National Laboratory is intended to present a general picture of a typical technical information organization at any one of the larger atomic energy research laboratories in this country. The main difference, in the case of Brookhaven, lies in the fact that the proportion of unclassified work to secret is somewhat greater than at other installations. This, of course, has had the effect of increasing our responsibility to disseminate information to the widest possible extent.

Before launching into a detailed discussion of the information work itself, it would be well first to describe the Laboratory's organization, and by this means indicate the requirements of our scientists. The Laboratory's technical staff is organized along lines very similar to those of a university faculty. There are Departments of Biology, Chemistry, Medicine and Physics. An Instrumentation and Health Physics Department is responsible for the design and construction of electronic equipment for research and for radiation safeguards. In addition, the Reactor Science and Engineering Department and the Accelerator Department were organized to design and subsequently to operate the two large research facilities, the reactor and the high energy particle accelerators. Thus, it can readily be seen that the demands on our technical information facilities, both internal and external, are extremely varied in their fields of interest. This situation is very similar to that at the other major AEC installations.

The main functions into which our efforts are directed are as follows:

(a) The operation of the Research Library, which comprises books, periodicals and other types of publications in the open literature. It is not necessary to describe this function in this paper.

(b) The control, as required by AEC's security regulations, of incoming and outgoing classified documents, and the operation of a small library of classified Project material.

(c) The production and distribution of technical reports (open and classified) issued under the auspices of the Laboratory.

(d) The processing of papers authored by Brookhaven staff members, intended for publication in the various open scientific journals.

The Classified Library

The second item, the Classified Library, immediately points up one of the great information problems facing all AEC laboratories—the classified report. At every stage of its existence, such a document must be watched and accounted for and properly safeguarded and only permitted into the hands of those authorized to have it, while on the other hand, it is also our responsibility to ensure that it receives the optimum distribution within

* Presented before the Middle-Atlantic Section of the ASEE, Rutgers University, May 12, 1951.

the existing security regulations. An additional handicap in this procedure lies in the fact that in many cases even the title is a classified item. With these obstacles, the surest way to bring such secret material to the attention of the proper persons is by means of personal contact. The staff of the Classified Document Group have been trained over a long period in the needs and special interests of the scientists; in addition, a great assistance is rendered by the AEC publication *Abstracts of Classified Reports,* which is issued bimonthly and is circulated at all project laboratories. This publication can be considered as the classified counterpart of *Nuclear Science Abstracts.*

In contrast to the difficulties under which classified reports must be circulated, the discussion of the dissemination of open literature comes as a pleasant relief. In this case there are no restrictions, the only problem being that of weeding out from the great mass of incoming material those items that are of greatest interest, thus saving the scientist's time and yet helping to keep him abreast of the literature. At Brookhaven, we have found *Nuclear Science Abstracts* and the *Weekly Selected Reading List* extremely valuable in this respect. The first, a fortnightly Commission publication, gives excellent general coverage on all unclassified and declassified material in the fields of nuclear science and engineering. At Brookhaven, we distribute 200 copies of each issue of *Nuclear Science Abstracts* on an individual basis, at the specific request of the recipients.

Nuclear Science Abstracts is supplemented by the Reading List, already mentioned, which, since it is prepared at Brookhaven, can give a more detailed coverage in fields in which the Laboratory is particularly concerned. The titles in this weekly list are broken down into the following categories: General, Physics, Engineering, Electronics and Instrumentation, Chemistry, and Biology and Medicine. Each Wednesday, the new material—books, periodicals and reports—are culled, both by the Library staff and by the scientists themselves. Each of the scientific departments has a list of those willing to help in the selection for his own particular field, and a turn is taken each week by one of those on the list. In this way, no great burden is placed on any one individual; in fact, some of the selectors have expressed their satisfaction with the system, as a means of giving them the necessary impetus to keep in close touch with the Library. In addition to the internal distribution of 220 copies of the *Reading List,* we have received over 600 requests from other laboratories and institutions connected with the atomic energy program.

While on the subject of the *Reading List* and *Nuclear Science Abstracts,* it should be mentioned that we have developed a system for bringing such publications to the attention of new staff members who might be interested in receiving them on a personal basis. At the time that a new scientific worker joins the Laboratory staff, a check list is sent to him, together with sample copies of the various publications he may receive regularly if he wishes, such as the *Reading List, Nuclear Science Abstracts,* and the monthly *Library Acquisition List.*

Reports and Translations

A separate unit within the Technical Information Division is concerned with the preparation of Brookhaven reports, both open and classified. Such reports can be broken down into the following categories: Laboratory progress reports; technical reports covering single phases of research; conference reports containing the papers presented at scientific conferences held under Laboratory sponsorship; and the *Guide to Russian Scientific Periodical Literature*

This last named item is worthy of particular mention, since it is somewhat unusual in its scope. Since early 1948, Brookhaven has been issuing translated lists of titles from the outstanding Rus-

sian scientific periodicals, notably the journals published by the USSR Academy of Sciences. Seven issues appeared during 1948, but since the beginning of 1949 the *Guide* has appeared on a basis of twelve issues per year, with a cumulative index included in the last issue for each calendar year. In addition, some translations of abstracts are also given, and, in certain cases, translations of full articles in the field of nuclear physics.

The project was originally instigated as a result of the abandonment in late 1947 by all Russian scientific periodicals of the practice of publishing in English the titles and abstracts of their articles. Previously, such material had been available in English, French, and German. In spite of this lack of cooperation on the part of the Soviet Government, it has still been possible, though not always easy, to obtain copies of their outstanding scientific journals within several months of publication. In addition, a number of other organizations in this country, Canada, and Great Britain are cooperating with Brookhaven by submitting to us copies of any Russian translations they may have made; the titles of such translated articles are listed periodically in the *Guide*, and are available for loan from the Research Library. While the *Guide* is proving very useful to a number of our physicists, particularly those concerned with cosmic ray work, it must also be considered as a service to all those interested in solving the mysteries of scientific research behind the Iron Curtain.

Distribution of Reports

After reproduction, the question of distribution naturally arises. In the case of secret reports, this is all too easy; copies are sent only to those organizations authorized by AEC to receive them. The Commission periodically issues lists of subject categories, with an appropriate distribution list for each category. Such distribution lists are rigidly adhered to. In the case of open publications, we feel, and are encouraged to feel, that we should give as wide a distribution within the atomic energy project as is necessary. Thus, we can distribute to any of our staff members or consultants who needs the material, any individual working at one of the universities or industrial installations cooperating with or holding a contract with the Commission, and the various cooperating government agencies. In addition, there are two standard distribution lists we follow automatically; one is the AEC list, and the other is the list of Government Document Depository Libraries authorized to receive all our unclassified material—some 200 public and university libraries located all over the country. Then, to make such material even more accessible to industry and the general public, copies are offered for sale by the Office of Technical Service, Department of Commerce, Washington, D. C., which is the properly authorized document sales agency for reports emanating from within the Commission's laboratories.

Another problem is presented by the papers written by Laboratory staff members for publication in the scientific journals. Naturally, when such a paper covers research conducted on AEC funds, it is necessary to ensure that the necessary checks for patent significance have been made, that it contains nothing of a classified nature, and that there is no statement that might be of questionable policy nature. At Brookhaven, these checks are made without undue delay by having the various departmental secretaries prepare the manuscripts on ozalid, so that sufficient copies can be run off for the checks to be made concurrently, with copies also available for the patent records, Director's files, departmental files, etc. When all the necessary clearances have been obtained, the paper is submitted to the journal, and a copy is also forwarded to the Commission's reproduction facilities at Oak Ridge, so that it can be abstracted in *Nuclear Science Abstracts*, and possibly reproduced

as an AEC document, if there appears to be a considerable delay before it can be published in the journal for which it is intended.

Technical Information Panel of AEC

This concludes the description of the main technical information service (apart from the Library) provided at one of the major AEC laboratories, but it only gives one side of the Commission-wide picture. No services such as ours could hope to be anywhere near adequate without the close cooperation of the other laboratories, or without the overall coordination of the Technical Information office in Washington. In such an enormous organization as AEC, with its laboratories so far removed from each other, and the cloak of secrecy so often intervening, it is vital that, by devious but carefully worked-out systems, workers can benefit to the fullest from work conducted at other laboratories, thereby also avoiding costly duplication of effort. How this can best be done is a problem which is shared equally by all information officers and librarians, and by the Washington Office of the Technical Information Service.

The Commission has wisely recognized this fact by creating a Technical Information Panel, made up of representatives from each of the major AEC research contractors, to advise AEC on all aspects of its technical information services. This Panel, with Dr. A. F. Thompson as chairman, meets three times a year to discuss technical information problems and to make the necessary recommendations towards improving our services. Material for the agenda for one of these meetings is solicited well in advance, the agenda is then made up and circulated to all Panel members. It is thus their responsibility before the meeting to discuss with all concerned at their laboratories—librarians, document custodians, editors, and of course, scientists—the items that concern them particularly, so that the members can come to the meeting fully prepared, not only with their own views as information officers, but with the views of the laboratories they represent.

I am pleased to state that the meetings are conducted in a truly democratic spirit, that no complaint or suggestion is offered without receiving proper consideration, and that the general sentiment of all members is that the Commission is far more anxious to act upon the recommendations of the laboratories than it is to impose its own ideas upon them. Surely this is the keystone of any large technical information program such as ours, and since there is every reason to believe that it will continue to be conducted in this fashion, we can hope to surmount successfully our future problems. However, we must always bear in mind the axiom that no technical information facilities, whether they be well-stocked libraries, well-written and handsomely printed reports, or carefully formulated distribution lists, will ever be any better than the services of the technical information staffs whose responsibility it is to make these facilities available to science.

Report of Vice President in Charge of General and Regional Activities, 1950-51

The following brief resume of the activities of your Vice President for General and Regional Activities during the year 1950–51 is submitted for the information of the General Council.

I. General Activities

A. *Engineering Enrollment Statistics*

Data on engineering enrollments and degrees were collected jointly by ASEE and the Office of Education for the second year. The February issue of the Journal of Engineering Education carried the Society's publication of these statistics. The Office of Education issued a bulletin similar to the one it issued last year. The Office experiences a strong demand for these reports.

B. *Engineering Manpower Commission*

Your Vice President has served throughout the year as one of the three representatives of ASEE on the Engineering Manpower Commission of the Engineers' Joint Council.

The Commission has given wide distribution to its Bulletin No. 1 entitled "Utilizing Engineering Manpower-Deferment Procedures" as a guide to industry. Representations have been made to the Congress with respect to the length of time during which persons deferred from military service shall be liable for such service.

The Commission is conducting a vigorous campaign to place before high school students and their teachers and advisors information about the true situation in the engineering profession. Two booklets dealing with the shortage of engineers have been distributed widely, and a third is in preparation, based on a telegraphic survey of industrial and governmental needs.

The Office of Education has issued a brief statement prepared by your Vice President under the title "Young Engineers for Industry—How Many," which was written at the direct request of the Engineering Manpower Commission.

C. *Point IV*

Your Vice President reported to the Executive Board in March that the State Department was planning to request various universities to assume responsibility for the educational phases of the Point IV program in the countries to which teams are to be sent. This policy has been changed and the State Department is now channeling its programs through various Federal agencies of which the Office of Education is one.

At least for the present the educational part of the Point IV Program will be focused upon basic requirements such as literacy education, basic vocational education, and home making. There will be a few instances in which college level teachers will be recruited, but the numbers will be small.

D. *Committee on Improvement of Engineering Teaching*

Your Vice President has served during the year as a member of the Society's Committee on Improvement of Engineering Teaching on the subcommittee headed by Provost Colburn of the University of Delaware. The activities of the committee will be reported elsewhere.

E. *Atomic Energy Education*

Your Vice President has served during the year as the Chairman of the Society's

Committee on Atomic Energy Education. A report was submitted to the Executive Board in March covering the meetings of four regional subcommittees of the Committee which had been held up to that time, and transmitting a "Memorandum for Information" prepared by the Chief of the Technical Information Service of the Atomic Energy Commission at the request of the Chairman and Secretary of the ASEE Committee.

On May 8 a meeting of the Steering Committee with several representatives of the Atomic Energy Commission was held in Washington. The minutes of this meeting were sent to the Officers of ASEE and a digest of the entire year's work of the Committee has been submitted for publication in the JOURNAL OF ENGINEERING EDUCATION. It is the belief of the members of the Steering Committee that a very useful purpose is being served by this Committee, and it is the recommendation of your Vice President that the Committee be continued.

II. REGIONAL ACTIVITIES

A. *Information and Suggestions to Sections and Branches*

In September a letter was sent to all Section and Branch Officers and General Council Representatives, containing minutes of the June meeting of the Committee on Sections and Branches, a report on the September meeting of the Executive Board, and suggestions for Section and Branch activities for 1950–51.

In January the first issue of the Clearing House Bulletin for Section and Branch Officers and Representatives was issued, containing news items of general society activities and descriptions of several Section and Division activities which it was thought would be of value to these officers in planning the activities of their respective organizations. It apparently was favorably received, and elicited some suggestions for topics to be discussed by the Committee on Sections and Branches at its meeting.

B. *New Branches*

New Branches have been approved during the year at the University of Tennessee and at Texas A. & M. College. A new constitution was approved for the University of Maine Branch, based on the model constitution prepared by the Committee on Sections and Branches last year.

C. *Section Meetings*

Sixteen meetings have been reported during the year by 13 of the Society's 16 Sections (The Mid-Atlantic Section has met twice, and the National Capital Area Section three times).

All meetings have had excellent programs and have been well attended. Section officers deserve the thanks of the Society for their effective contributions to this important phase of Society activities.

At least one national officer has been in attendance at each meeting save one, when unforeseen events forced changes in plans of two officers who had expected to attend. It is hoped that this evidence of interest in Section meetings will continue in future years.

D. *Committee on Sections and Branches*

This Committee held a meeting on November 15, 1950, which was devoted in part to a discussion of the constitutional amendments providing for Associate and Affiliate Branches which were at that time under consideration, but which have since been tabled by the Executive Board.

The Committee also considered a proposal that Sections assume responsibility for the conduct of summer schools. The Committee recommended that such schools should be sponsored primarily by one of the subject matter Divisions of the Society, as they have been in the past, since a Division is interested in one particular field of education, whereas a Section might be characterized as a miniature national society interested in all phases of engineering education. However, the Committee felt that a Section might ac-

tively aid a Division in organizing a summer school if it saw fit and if satisfactory arrangements can be made between the Section and the Division. This recommendation of the Committee was endorsed by the Executive Board at its meeting later the same day.

The Manual for Section Officers which was prepared by the Committee last year is apparently proving useful to Section and Branch officers, and copies have been requested by officers of two Divisions. It is suggested that the Committee might well study the Manual further over the next year or two, with a view to possible revision and publication as an official Society document.

The Committee met on June 25, 1951, to outline plans for its activities during 1951–52. It is your Vice President's sincere belief that a major factor in the vitality and strength of our Society lies in the Sections and Branches. He feels that the reorganized Committee on Sections and Branches has already made a contribution to the Society, and is in a position to be even more useful in the future.

III. Appreciation

Your Vice President cannot conclude his two-year term of office without expressing his deep gratitude for the wholehearted cooperation he has received from the other national officers with whom he has served, from the officers of Sections and Branches, and from the members of the Committee on Sections and Branches. Whatever degree of success has attended his efforts to serve our Society has been in large measure due to the inspiration, guidance and cooperation of these gentlemen. He can wish his successor no better fortune than that he be favored with a continuation of the same cooperation.

Respectfully submitted,

Henry H. Armsby,
Vice President in charge of General and Regional Activities

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Report of the Vice President for Instructional Activities of ASEE, 1950–51

The vice president for instructional activities maintains contact with Committees and Divisions, with the development of Summer Schools, and with the planning of the program for the Annual Meeting. These items will be taken up in inverse order.

The Program of the 59th Annual Meeting. Although this program is officially a responsibility of the vice president the detailed work of organization should be and has been carried out by the secretary. The function of the vice president has been restricted to consulting with the secretary when difficult decisions were to be made. This has been readily possible because of the locations of their respecfive offices in Chicago, and Evanston, Illinois. The Preliminary Program indicates that there will be very broad coverage of the field of engineering education at the Annual Meeting. The Secretary deserves to be complimented on the early publication date of the preliminary program which will have a major influence upon attendance at the 59th Annual Meeting.

The Summer Schools. Early in the year the vice president recommended approval of three summer schools and one summer conference for 1951. These were approved by the Executive Committee in October 1950, and they will be found listed in the official program on pages 30–31. In brief summary these summer schools will have the following objectives.

(1) Humanistic-Social Division Summer School, to be held June 21–23, 1951. The program is devoted to the consideration of the general problems involved in planning, developing, and teaching courses and integrated sequences in the humanities and social sciences to students of science and engineering.

(2) Engineering Drawing Summer School, June 21–26, 1951. The general theme will be "Improving our Status as Teachers of Engineering Drawing." This includes: (a) Meeting curriculum requirements; (b) Teaching methods by lecture demonstrations, and (c) Industrial applications.

(3) The Summer School in Thermodynamics will be held June 28–July 7, 1951. Topics include elementary thermodynamics, theory and advanced theory, with emphasis upon newer trends.

(4) The Civil Engineering Division is planning a conference prior to the Annual Meeting on June 23–25, 1951. The program indicates conference papers on teaching as a career, teaching techniques, electives in civil engineering and textbook selection and evaluation.

It is worthy of comment that the multiple summer-school plan shows a very healthy growth. The vice president feels that the Council made a wise decision in permitting the development of multiple summer schools. No attempt has been made to promote such summer schools, the growth observed is therefore entirely spontaneous. In this connection mention should also be made of the Fontana Summer Conference sponsored by the Southeastern Section which your vice president attended in 1950. This conference is of broader scope than the conferences mentioned above so that it attracts teachers from all fields of engineering. Another conference intended quite specifically to improve teaching and directed primarily toward young teachers was

held at Madison, Wisconsin in the spring of 1951 under the sponsorship of the North Midwest Section. It seems clear that both of these sectional conferences have served purposes similar to Summer Schools and should, therefore, be encouraged.

Committees and Divisions. The vice president for instructional activities has had regular correspondence with Division and Committee chairmen concerning such matters as Division publications, the sponsorship of summer schools, the character of the annual program, etc. Since officers rotate rapidly certain questions will need to be answered every year. It is well, therefore, for the vice president to have had considerable experience himself in Division activity.

The Special Committee on Instructional Aids. At the request of the subcommittee on Visual Aids of the Division of Educational Methods and with the approval of the Division a special committee on Instructional Aids was approved by the Executive Committee to function for a limited period of time. This committee under the chairmanship of Professor Carl Muhlenbruch of Northwestern University is now raising funds from industry to publish an index of available and approved instructional aids. The response of industry has been gratifying and the completion of this special project seems assured. This special committee will terminate its activities with the completion of this project since the Division of Educational Methods will maintain a permanent sub-committee covering this field.

The Council Committee on Improvemen of Teaching. This special committee whose establishment was approved by the Council in 1949 was not appointed as an active committee until a year ago. It had been preceded by a steering committee which effectively set the objectives for the main committee. Since the vice president for instructional activities has also served as chairman of this special committee during the past year this report will serve a two-fold purpose.

The Committee for Improvement of Engineering Teaching met for the first time at Seattle in June 1950. A list of members of the Committee is appended hereto. At Seattle it was decided to subdivide the committee into three subcommittees for convenience in meeting, each having the following objectives.

Group I meeting in New York under the Chairmanship of Dr. Alan Colburn was asked to study the problem of improvement of teaching by giving emphasis to the integration of work in the classroom, laboratory and drafting room primarily through the use of common scientific principles or basic laws. This committee is also interested in integration between fields and departments.

Group II meeting in Pittsburgh under the Chairmanship of Dean H. P. Hammond undertook to give special attention to teaching methods and techniques as influenced by such factors as class size, course objectives, limitations of physical equipment, etc. Such techniques include lecture, demonstration lecture, recitation, squad or group projects, blackboard assignments, etc. The evaluation of these techniques is being made on the basis of fundamental principles of learning.

Group III meeting in Evanston under the Chairmanship of Dr. John Calvert is investigating the development of ingenuity and resourcefulness in the student, emphasizing the importance of developing a capacity to design for most students and of research capacity for at least some.

Sub-committee Meetings. During the academic year 1950–51 Group I met twice in New York, Group II met twice in Pittsburgh, and Group III met once at Evanston, Illinois. In addition, the general chairman held a special group meeting for orientation following the ASME fall meeting in New York. The result of these sub-committee meetings is that three reports have been written which will guide the overall committee in its decisions at East Lansing, Michigan regarding how the work of the Committee shall be completed.

Institutional Committees. It was decided at Seattle to ask each engineering institution to cooperate with the ASEE Council Committee by appoining an Institutional Committee on Improvement of Teaching. Eighty of our deans of engineering have replied to your chairman's request and have furnished the names of institutional committees or of the chairman. The evidence points to the fact that well over 100 institutions have appointed such committees but some have failed to notify your chairman of their actions. Some thirty reports were received from these institutional committees on their studies, and these reports have been digested by the three groups or sub-committees. It is clear to everyone concerned that the great activity on institutional campuses during this year which was directed toward improvement of teaching is the most significant part of your Council Committee's work. We hope to stimulate continued activity of this nature into 1952.

East Lansing Meeting June 23–24. The Council Committee on Improvement of Teaching will meet in East Lansing for two days preceding the Annual Meeting. Sub-committee reports will be received and plans will be drawn for the completion and writing of a final report. The Committee expects to make its final report to the Annual Meeting at Dartmouth in 1952.

Other Activities at the Annual Meeting. The Committee for Improvement of Teaching has arranged a luncheon and discussion meeting on Monday, June 25 with representatives of institutional committees concerned with improvement of teaching. This will be a valuable opportunity for your Committee to learn of local or institutional thinking. On Wednesday, June 27, your Committee will report to the ASEE membership at the General Session. And on Thursday, June 28, the Committee will jointly sponsor a meeting of Young Engineering Teachers devoted to improvement of teaching.

This completes the activities of this Council Committee for 1950–51. If it is your desire to continue its activities it appears probable that they can be completed during 1951–52 and that the Committee should be discharged at the time of the Annual Meeting in 1952.

The above completes the report of the vice president for instructional activities for the year 1950–51.

Respectfully submitted,

L. E. GRINTER,
Vice President in charge of Instructional Division Activities

Cooperative Division to Hold Third Annual Mid-Winter Meeting

The Cooperative Division of the ASEE will hold its Third Annual Mid-Winter Meeting at Northwestern University, November 8th and 9th. The program is planned to be a part of the Technological Institute's program in the Centennial celebration of Northwestern University this year.

Annual Report of the Engineering College Administrative Council, 1950–51

Meetings

The Executive Committee to date has held two meetings as follows: Carlton Hotel, Washington, D. C., November 16, 1950; Palmer House, Chicago, Illinois, March 14, 1951. There was one hundred per cent attendance of committee members at the meeting in November, and all members except one were present for the meeting in Chicago in March.

The Washington meeting was held in conjunction with the regular fall meeting of the Engineering College Administrative Council, which by custom is held immediately following the Land-Grant College Association meeting. The March meeting of the Executive Committee was held in Chicago which seemed to be a more central location for all of our members. It was held immediately preceding the General Council meeting and we had the pleasure of the presence and the benefit of the counsel of President Dawson and Secretary Bronwell.

It is especially to be noted that it was necessary for the Executive Committee to elect a new man to its membership due to the resignation of Dr. T. Keith Glennan. This election occurred at the fall meeting. At the spring meeting the Executive Committee authorized the formation of a Nominating Committee to consider and recommend nominees for certain offices of the Engineering College Administrative Council. These offices are: chairman, secretary, and one member of the Executive Committee, all for two-year terms. The retiring member of the Executive Committee is Dean R. E. Vivian. These new officers will take office July 1, 1951. Recommendations for them will be presented and election held at the business meeting of ECAC at East Lansing, Michigan, in June.

Fall Meeting.—The fall meeting of the Engineering College Administrative Council was held at Washington, D. C., November 16, 1950, 2:30 P.M., at the Carlton Hotel. The theme of the program was "Mobilization of Engineering Education." It presented governmental, industrial, and educational attitudes, operating procedures, and plans to meet the critical manpower problems due to our expanding defense and armament program. The meeting was well attended, approximately two hundred being present. Details of this meeting are shown as Appendix II.

Annual Meeting.—Michigan State College, East Lansing, Michigan, June 25–29, 1951. The program as planned for the Engineering College Administrative Council's activities as part of the annual meeting included a business meeting of the Committee on International Relations with W. R. Woolrich presiding on June 26, and an Executive Committee meeting for members of the Committee and officers of the Society only. A joint ECAC Meeting of the Committee on Secondary Schools and Selection and Guidance was held on June 27 with W. S. Evans presiding. On June 28 the ECAC General Session had as its theme, "Manpower and Military Problems in Relation to Engineering." J. H. Lampe, Secretary, ECAC, presided. This was followed by a joint meeting of the Military Affairs and Manpower Committee with L. E. Grinter presiding. On June 29 an Executive Session for institutional representatives only was held with F. E. Terman presiding.

The Executive Session which was held in Seattle in June, 1950, was very successful. Many administrative problems of wide interest were discussed and effective comments were received from administrators of all sections of the country. The success and helpfulness of the Executive Session last year led to the planning of another special meeting for institutional representatives only. The following topics were discussed: A. Washington Report —Uncensored, which was an off-the-record report from Dean Saville; B. Special Problems of 1951–52, which dealt with accelerated programs, lower enrollments and staff reductions, business and administrative problems, under current conditions, faculty status of senior research men, salary policy, etc.; C. "Administrative problems arising from expanded research activities in the schools; D. General problems—"Up or out" plan for faculty tenure, placement service for engineers—how to operate, functional activity, how should faculty take part?

Projects of the Year

At the Executive Committee Meeting in Washington on November 16, 1950, it was decided to conduct a survey on the June, 1950, engineering graduates to determine where these men are now located professionally. This work is being done by the Manpower Committee headed by Mr. George D. Lobingier, chairman. The Manpower Committee, in conjunction with the Engineers' Joint Council, has also worked on the problem of increasing the interest of high school students in engineering as a career.

The Selection and Guidance Committee in conjunction with the Engineers' Council for Professional Development is making a study on the best way that ECAC can help in proper guidance in placement activities in the engineering colleges. Further, the Committee has worked with the Educational Testing Service on the Pre-engineering Inventory Tests.

The Committee on International Relations upon a request from the Army to nominate engineering educators for a fifteen-man panel to go to Japan for two months in the summer of 1951 organized a Commission under Dean Hammond. This Commission was headed by H. L. Hazen.

The ECAC sponsored the circulation of the bulletins of the American Council on Education to all institutional members.

News Bulletin

During the past year the ECAC *News Bulletin* was circulated six times to our institutional, associate, and affiliate members and to the ASEE officers and council members.

Informational Announcements

(I) Executive Committee Meeting, June 27, 1951

(a) *Military Affairs Committee.* In view of the immediate need for work with Federal groups and agencies with respect to Universal Military Training, a new committee for 1951–52 was immediately appointed. The Committee is as follows: W. Allan, Chairman; Messers Davis, Hawkins, Trytten, White, Norris and Wessman. Additional members may be appointed in the near future.

(b) Chairmen for other ECAC mittees for 1951–52 are:

Secondary Schools, W. S. Evans;
International Relations, L. J. Lassalle;
Selection and Guidance, H. R. Beatty;
Manpower, George Lobingierx.

(II) Business Meeting of ECAC

This meeting was held on June 28, 1951. Dean Barlow, Chairman of the Nominating Committee, made the rec-

ommendations and the following were elected for the term and office indicated:

J. H. Lampe, Chairman of ECAC and Vice-President, ASEE (term expires July 1, 1953);

W. L. Everitt, Secretary (term expires July 1, 1953);

W. T. Alexander, new member of Executive Committee (term expires July 1, 1953).

Respectfully submitted,

F. E. TERMAN, *Vice-President of ASEE in Charge of ECAC*

J. H. LAMPE, *Secretary, ECAC*

Fall Meetings **Fall Meetings**

ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL
ENGINEERING COLLEGE RESEARCH COUNCIL
GENERAL COUNCIL

November 15, 1951 **Rice Hotel, Houston, Texas**

The ECAC along with the ECRC and the General Council will hold meetings at the Rice Hotel, Houston, Texas, Thursday, November 15, at 2:00 P.M. These meetings will immediately follow the annual meeting of the Association of Land-Grant Colleges and Universities, which will be held at the Rice Hotel from Monday, November 12, until Thursday noon, November 15, inclusive. Members of the ASEE are invited to attend the ECAC and ECRC meetings. The meeting of the General Council is the usual fall business meeting.

The ECAC Session will deal with proposals for the development of close working relationships among engineering colleges, high schools and junior colleges. Such relationships are becoming increasingly important, since they vitally influence the quantity and quality of students entering engineering colleges.

The main theme of the ECRC Session will be "Current Problems in University Research Relations." Primary attention will be given to:

1. Developments in contract relationships with the Federal Government;
2. Discussions of Basic Research in Engineering, particularly as may be related to the National Science Foundation Program;
3. General report on Washington research activities.

Report of the Engineering College Research Council, 1950–1951

The activities of the Research Council during the past twelve months have been set against the background of an unprecedented national need for the products of engineering and scientific talent. We are caught in the vise between greatly augmented needs of all kinds of engineering production and research—and decreasing numbers of men trained for these vital assignments. Though the real pressure from these factors is still ahead, in this environment the Research Council has already found new responsibilities and some of our greatest opportunities.

During the Fall, as the first phases of industrial and scientific mobilization were completed, the Research Council was represented at a series of conferences on the problems and responsibilities of educational institutions. These were climaxed in Washington in November, at the fall meetings of the American Society for Engineering Education, when the Research Council sponsored a panel discussion by principal federal officials concerned with research and development needs. Since that time we have continued active liaison with these federal agencies involved in the procurement of engineering research. In this work we have sought to supplement and guide the contacts of individual institutions—and to encourage them to seek the benefits of direct discussions.

We have recently completed the third volume in the continuing biennial series of "Review of Current Research," and this project, too, derives added urgency from its environment. With research and development needs outstripping our national capacity, it is important that we know what is being done, how, and where. We cannot now afford the luxury of duplication and repetition.

The 1951 "Review of Current Research" reflects the startling growth of engineering research in our member institutions. This year's book lists over 5200 individual research projects, the work of more than 11,500 faculty, graduate students, and research engineers. These projects are responsible for annual expenditures of $50.5 million in the 92 institutions now qualified for Engineering College Research Council membership. This is a growth of more than $15 million in a two-year period, and an increase of over 1000 projects and 1500 research workers.

Amendments to the By-Laws providing for the organization of regional sections of the Engineering College Research Council were approved during the past year. We hope that the new groups thus made possible may assist in the development of research activities in smaller engineering schools which do not qualify for Active Membership.

The Research Council's second major project during the current year has been the accomplishment of the Committee on Relations with Military Research Agencies, of which Dean A. F. Spilhaus is Chairman. Following the Washington meeting in November, this Committee was encouraged by the Research and Development Board to undertake an inventory of the resources for scientific and engineering research in American colleges and universities. Now for the first time, as a result of this work, we know the research potential of more than 500 educational institutions in these critical fields. We know the number of

faculty members and senior students qualified and available for research in the various fields of science and engineering at each school; we know the special areas in which these people are particularly interested and prepared to do research; and we know something of the kind of equipment with which they have to work.

It is far too early to estimate the effectiveness of this substantial project, but we are certain of its potential value to American higher education and we are assured of its importance to national defense.

The Committee has catalogued a substantial reserve of research potential in the smaller engineering and liberal arts institutions throughout this country which have thus far not been able to contribute their share of our research and development needs. Even in larger schools we have found an important reserve. I am confident that this project can make possible a more equitable distribution of research and development responsibilities to all colleges, can assure that colleges may maintain their scientific staffs by providing research opportunities in line with professional interests, and promises that scientific and technical education throughout the nation may be strengthened and enriched at a time when its product is most needed.

During the coming months the demands on educational institutions for research and development will be greatly augmented. It is important, in this period of increasing pressure, that all colleges and universities fulfill their responsibilities to the nation with seriousness and effectiveness. It is particularly necessary that, in so doing, they maintain their academic and fiscal integrity. We must obviously guard against poor research achievements; as our volume increases, and the pace of our tasks mounts, we must not permit standards to fall.

And we must maintain our positions as *educational* research organizations. For this is not merely a time when America needs the results of research and development. The vise which makes our present situation especially grave is that we need not only these new advances which can result from today's studies. We desperately need many, many more men qualified to do all kinds of research, and we as desperately need the fundamental information on which the developments of tomorrow will be based.

The tremendous amount of development and applied research required immediately by the national defense presents a challenge to all America's research facilities. In the colleges and universities these immediate demands should not displace the longer-range fundamental research which is traditionally our principal concern. Our task is to develop programs fulfilling, in as full measure as possible, both these needs.

In accepting our research and development obligations, we in colleges and universities must not submerge our roles as educational institutions. We must undertake our new tasks and, at the same time, we must exert every effort to make our teaching and research more effective —in terms of graduates still better equipped to contribute to the national welfare, and in terms of fundamental engineering science on which the nation may base its future progress.

GERALD A. ROSSELOT,
Vice President of the ASEE
in Charge of the ECRC

Secretary's Report 1950–51

Despite the growing emphasis upon mobilization, the Society, during the past year, has endeavored to maintain a reasonable balance between the urgent problems of mobilization and the long-range activities associated with the improvement of engineering education. An effort has been made to work closely with administrators of engineering colleges; and to keep them informed of latest developments and to seek their counsel on national affairs affecting engineering Education.

The Administrative and Research Councils of the Society have carried most of the responsibility of the problems arising out of the mobilization program. Reports on their activities are given elsewhere in this issue of the JOURNAL; hence the following deals only with the general activities of the Society.

Engineering Manpower

Probably the foremost problem of the ASEE during the past year has been that of alerting government officials and the public as to the serious consequences of the impending engineering manpower shortage. The fiction of a large oversupply of engineering graduates, resulting from the GI avalanche of June, 1950, had gained widespread acceptance by government officials and the public. The total employment of the 1950 graduating class and the subsequent development of serious shortages of engineers, coupled with the abnormally low engineering student registrations, made it imperative that the ASEE take aggressive action.

In November, 1950, the Administrative Council of the ASEE held a meeting in Washington, D. C. dealing with the subject of the critical shortage of engineering manpower. Leading government officials were invited and a number of these appeared on the program. Also at the time of this meeting, the Coordinating Committee of Relations with the Federal Government arranged a meeting between members of their committee, the officers of the Society, and government officials in the Department of Labor, Department of Defense, Federal Security Agency and Department of Commerce. At this meeting, the problems associated with manpower shortages, the draft, and emergency educational programs were discussed. Following the meeting, the Department of Labor issued a public release which reversed their previous predictions and emphasized a growing shortage of engineering manpower.

In November, 1950, an article and editorial dealing with the critical shortage of engineering manpower appeared in the *New York Times,* based upon statistics supplied by Dean Hollister. The ASEE supplied over 160,000 reprint copies of this article and editorial to engineering colleges throughout the country for redistribution to high schools.

Subsequently, an Engineering Manpower Commission was formed by the Engineers' Joint Council to prepare a report on the military and industrial needs for engineering manpower and to correlate this with the supply of graduates from engineering colleges. It was also the function of the Manpower Commission to prepare specific recommendations for alleviating the shortage. The recommendations of this Commission and the testimony presented before congress have had a profound influence upon the thinking

of government officials and congressional people on the whole problem of engineering manpower. The Engineering Manpower Commission has prepared a program of recommendations, has issued numerous public releases, has presented tstimony before congressional committees, and has embarked upon an extensive program to inform high school students and counselors of the potentialities in the engineering fields.

While the accomplishments of the ASEE and the Manpower Commission have resulted from the efforts of many persons, special credit must be accorded Dean Hollister for having crystalized the thinking on this problem and having taken the leadership in bringing the attention of the engineering societies to focus on the problem.

Improvement of Teaching

The Committee on Improvement of Teaching, under the chairmanship of Dr. Grinter, has made significant progress. The work of the Committee has been divided into three sub-committees under the chairmanship of Dean H. P. Hammond, Dr. J. F. Calvert and Dr. A. P. Colburn. At the request of Dr. Grinter, a number of engineering colleges have appointed special committees to study methods of effecting the improvement of engineering education and also to supply information to the Society's committee. An interesting and illuminating report will be forthcoming from this committee in the near future.

ASEE Commission on Engineering Education to Japan

At the request of the supreme commander for Allied Powers, the ASEE, in cooperation with the Unitarian Service Committee, has organized a commission of fifteen engineering educators to visit Japan. The commission will consult with the Ministry of Education of the Japanese government and officials and educators of Japanese universities. Harold L. Hazen, Head of the Department of Electrical Engineering at the Massachusetts Institute of Technology, will serve as chairman. The Unitarian Service Committee was appointed by SCAP to handle all U. S. Government administrative relations. The commission was organized by H. P. Hammond, Dean of Engineering, Pennsylvania State College. The commission members include: C. W. Beese, A. B. Bronwell, W. R. Chedsey, A. G. Christie, A. B. G. Dietz, B. F. Dodge, H. L. Dodge, R. B. Finch, H. L. Hazen, A. L. Miller, J. A. Sauer, E. W. Steel, H. B. Walker, F. L. Wilkinson and R. S. Williams.

Educational Testing Service

The ASEE Committee on Selection and Guidance, under the chairmanship of Professor Russell Beatty, has worked closely with the Educational Testing Service on the construction and publication of new Pre-Engineering Inventory tests. They have proven to be reasonably predictive of scholastic success in engineering. The Selection and Guidance Committee has contacted the individual examining officers in each of the accredited engineering colleges of the country, as well as the engineering deans, in order to familiarize them with the tests available and to encourage their adoption.

Teaching Aids Committee

The Committee on Teaching Aids of the ASEE, with Professor Carl Muhlenbruch as chairman, has successfully completed a fund-raising campaign to finance the program of evaluation of teaching aids. The work of the Committee, during the next year, will enter the second phase, that of the evaluation of teaching aids available for engineering instruction and the publication of a bulletin listing recommended teaching aids. Reviewing committees have been appointed in five curricular areas. An exhibit of teaching aids is being planned for the Annual Meeting at Michigan State College.

Unity of the Profession

The committee on Unity of the Profession, organized by the Engineers' Joint Council, has submitted its report. The report presents four alternate proposals for an organization to unify the engineering profession. These proposals have been submitted to the participating engineering societies for expressions of opinion of the society officers and members. After the opinions have been received, the Committee will resume its meetings in an effort to draw up a plan of organization which shows the greatest promise of successful adoption. The ASEE representative, Dean Thorndike Saville, has actively participated in the Committee deliberations and has served on the planning committee which drew up the proposals.

Mid-Year Meetings

The ECAC and ECRC held meetings in November in Washington, D. C. The Administrative Council's program dealt with the engineering manpower shortage and included on its panel of speakers officials in various government agencies. The ECRC meeting was devoted to a discussion of research facilities and potential, with emphasis upon the problems associated with defense research projects. These meetings were attended by approximately 300 administrators and faculty members of engineering colleges.

The Division of Relationships with Industry held a highly successful mid-year meeting in Cleveland, Ohio on January 20, 1951. The theme dealt with industry's requirements for engineering manpower, the draft, and the mobilization program. This meeting was attended by 200 representatives from industry and colleges.

The Drawing Division held its annual mid-year meeting on January 18–20 at Texas A. & M. College. Approximately 90 persons attended.

The cooperative Education Division held a meeting of representatives of fourteen schools offering cooperative engineering programs at the University of Florida on June 9–10, 1951. The meeting dealt largely with the type of training programs which industry should provide for cooperative engineering students. Proposals and problems of cooperative relations in civil service were also discussed.

Committee on International Relations

The Committee on International Relations, under the Administrative Council, has planned a meeting of international educators in conjunction with the Annual Meeting of the ASEE. Invitations were sent by Dean Woolrich, chairman of the Committee, to engineering educators in countries of the world outside of the Iron Curtain. It is becoming increasingly apparent that the ASEE can serve as a constructive influence in helping the nations of the world to get a deeper understanding of what constitutes engineering education and thereby improve their own educational systems. The Society can also serve as an international forum for engineering educators, thereby aiding in the dissemination of knowledge and fostering goodwill among engineering educators in many lands.

Renewal of George Westinghouse Award

The Westinghouse Educational Foundation has renewed its agreement with the ASEE providing for the granting of an annual George Westinghouse Award for another period of five years. This award consists of $1,000 and a certificate, presented to a recipient selected by the George Westinghouse Award Committee of the ASEE. The Committee has set an age limit of 45 for this award in order to serve as an encouragement for younger teachers.

Summer Schools

Three summer schools have been formally approved for ASEE sponsorship by the Executive Board. These are sponsored by the Humanistic-Social Division, the Engineering Drawing Division, and the Mechanical Engineering Division (Thermodynamics).

Cooperation with Other Organizations

The ASEE continued its active cooperation with other educational and engineering societies. A contribution was made to the Engineers' Council for Professional Development to assist it in instituting a program of professional training for young graduate engineers in industry. This program has been supported by a number of other engineering societies and will probably be launched in 1951–52. Its purpose is to encourage industry and universities to set up educational programs for young engineers in order to enable them to continue their professional growth in the years immediately after graduation.

Representatives of the ASEE have also taken an active part in the affairs of the Engineers' Joint Council, the American Council on Education, the American Standards Association, and other organizations.

Atomic Energy Conferences

A highly successful enterprise during the past year has been the conferences of the regional Atomic Energy Committees, organized under the chairmanship of Dr. Armsby. These committees have established an effective working liaison between the colleges and the atomic energy laboratories, providing for a flow of technical information on atomic energy to the college faculties. A series of papers on atomic energy, arising out of the conferences, has been published in the Journal and others are to follow.

Society Finances

Inflationary times are always difficult times for engineering societies and the ASEE is no exception. During the past four years, prices have almost doubled, but the ASEE has continued to operate with a balanced budget, despite the fact that its dues are approximately one third of those of other engineering societies. This has been made possible only by conducting a vigorous membership campaign, thereby increasing the Society income, and by keeping overhead costs to a minimum. Over 3500 new members have been added to the membership rolls in the past four years. It appears quite probable that the Society is approaching a saturation point in its membership and that there may even be some decline. This appears evident from the fact that the rapidly declining college enrollments will inevitably be coupled with a decline in the number of college teachers. It also appears doubtful at the present time that the general price level will remain stationary. The Society has been notified of an eight per cent increase in the cost of printing of the JOURNAL, an item which consumes over one-half of the total Society income, and other Society expenses are increasing proportionately. It therefore appears that more stringent circumstances lie ahead. The Executive Board is keenly aware of the financial problem and is making a serious effort to maintain a balance between income and expense.

Officers Activities

A final word of commendation is in order for the energetic and constructive activities of your officers and particularly your President. During the past year, President Dawson personally visited numerous Sections and Division meetings and attended most of the intersociety engineering meetings. He has exerted a constructive and beneficial influence wherever problems arose which impinged upon engineering education.

Respectfully submitted,

ARTHUR BRONWELL
Secretary

TIMELY TIPS

TIMELY TIPS *is a new section in the Journal devoted to unique ways of teaching difficult concepts so that they can be easily grasped by students. Contributions to this section should constitute an improvement over current textbook presentations. They should not exceed two Journal pages in length (including illustrations). If you have novel, short-cut methods of making difficult concepts seem simple, your colleagues will be glad to see them in the Journal. Send contributions to the Editor, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.*

Four Methods or One in Teaching Deflections?

By M. W. JACKSON

Assistant Professor of Civil Engineering,
University of Colorado

The principles of Virtual Work, Dummy Load, Conjugate Beam, and Area Moments for the calculation of deflections are too often considered in teaching as if they were entirely different. The names are more confusing than are the methods. If the interrelationships between them were better understood, it would perhaps simplify the study of deflections and rotations in courses in Strength of Materials and Indeterminate Structures. The following is a simple demonstration for comparing all four methods.

The beam shown in Fig. 1(a) is considered perfectly rigid except for the portion dx. It is desired to find the deflection of point C caused by the elastic deformation of the differential portion of the beam, dx. The usual assumptions in the solution of engineering structures are applied, that deflections are small, that the difference between the angle of rotation, the sine, and the tangent of the angle is negligible, and that the assumptions of the flexure formula apply.

There is an internal or resisting moment, M, at the section dx due to the applied loads, P_1, P_2, and P_3, which is equal to the applied moment. It has been shown prior to the study of this topic in the usual course in elementary strength of materials that $\frac{M\ dx}{E\ I} = \theta$. The angle, θ, as shown in Fig. 2, is the angle of rotation of adjacent faces of a differential element, dx, of a beam over which M is assumed constant. The assumed beam (rigid except for the elastic section dx) will deflect due to rotation of the faces of the element into the position AEB as shown in Fig. 1(b). Then,

$$\alpha = \tan \alpha = \theta \frac{\overline{AD}}{L}.$$

$$\Delta_c = \alpha \overline{CB} - \theta\, \overline{CD} = \theta \frac{\overline{AD}}{L} \overline{CB} - \theta\, \overline{CD}.$$

Simplifying,

$$\Delta_c = \theta \left(\frac{\overline{AD}}{L} \overline{CB} - \overline{CD} \right). \qquad (1)$$

The relation in equation (1) is purely geometric and will be the same no matter how the angular deformation θ is produced. Study of the quantity in the parenthesis in equation (1) is the point

of departure for obtaining the equations for the different methods of calculating deflections.

If a 1 pound load is applied at C as shown in Fig. 1(c), the reaction at A is $\frac{\overline{CB}}{L}$, and the moment at D due to this 1 pound load is $m = \frac{\overline{CB}}{L}\overline{AD} - \overline{CD}$. In other words, m is the bending moment at D due to a 1 pound load applied to the beam at C. Substituting m in equation (1), $\Delta_c = \theta\, m$. The value of m is an arbitrary value independent of the actual deformation of the beam or the actual loading of the beam.

The actual loads on the beam, P_1, P_2, and P_3, produce a bending moment, M, at section D, with a corresponding angle change θ between the parallel faces of the element equal to $\frac{M\,dx}{E\,I}$. Therefore the deflection at C due to the actual loads on the beam (considering only the dx portion elastic) is $\Delta_c = \frac{M\,dx}{E\,I}\,m$.

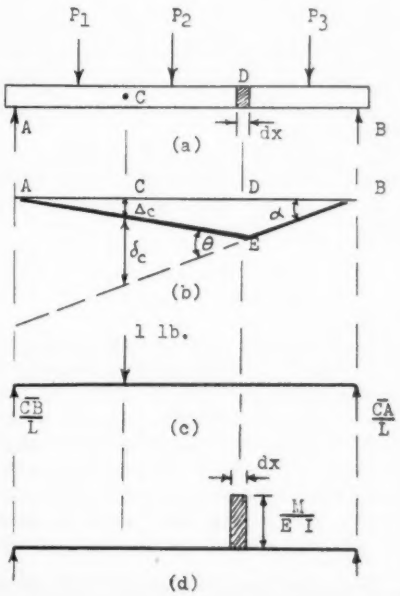

Fig. 1.

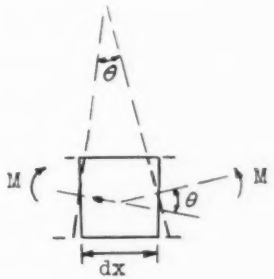

Fig. 2.

If the beam is now considered elastic throughout its entire length, the effect of the bending moment on each differential element will produce an angular deformation of that element and a corresponding deflection at C. Summing the deflections produced by each element, $\Delta_c = \int \frac{M\,m\,dx}{E\,I}$. This equation will be recognized as the basis for virtual work, the dummy unit load method, Maxwell-Mohr method, elastic energy, and others likewise of different names but utilizing the same final equation.

Equation (1) has another interpretation. As shown in Fig. 1(d), a load equal to $\frac{M\,dx}{E\,I}$ is applied to the beam at D. This load, or *area*, produces a rotation θ of the adjacent faces of the element, dx, since $\theta = \frac{M\,dx}{E\,I}$. The reaction at B of the beam thus loaded is, $\theta\,\frac{\overline{AD}}{L}$. The bending moment about C (considering the right hand portion of the beam) is $\theta\,\frac{\overline{AD}}{L}\,\overline{CB} - \theta\,\overline{CD}$, which is equal to Δ_c in equation (1). Therefore the deflection at C due to $\frac{M\,dx}{E\,I}$ applied as a load to the beam at D is equal to the bending moment at C due to that load on the beam. If then the entire beam is con-

sidered elastic and the $\frac{M}{E\,I}$ diagram for the actual loading is applied to the entire beam as a load, the deflection at C is the bending moment at C produced by this load. This will be recognized as a conjugate beam proposition and as the method of elastic weights.

Fig. 1(b) may also be used to demonstrate an area-moment relationship. From the geometry of the figure, $\delta_e = \theta\,\overline{CD}$. Since $\theta = \frac{M\,dx}{E\,I}$, due to the loads on the beam, $\delta_e = \frac{M\,dx}{E\,I}\,\overline{CD}$. Consequently it may be said that the deflection of C from a tangent through D is equal to the moment about C of the area $\frac{M\,dx}{E\,I}$ applied at D. It may be seen that angle changes between A and C, and between D and B, do not affect δ_e. Considering the effect of all of the angle changes between C and D, the angle θ for each differential element is produced by the moment on that element due to the applied loads. Therefore, it may be said that the deflection of C from a tangent through D is equal to the moment about C of the area of the $\frac{M}{E\,I}$ diagram between C and D. This is one of the area-moment principles.

Some steps desirable for a rigorous proof of any of the above propositions have been omitted here to save space, but the main parts have been outlined. Similar procedures may be used to establish the relationships for rotations for any of the above systems.

Big Numbers and Little Numbers

By R. E. NEWTON[1] AND H. R. GRUMMANN[2]

30,000,000 is a big number and 0.0000065 is a little one, yet both are typical magnitudes of concern to the engineering student and practicing engineer alike. Faced with the stark necessity of dealing with such numbers within the confines of finite sheets of paper and still not loosing track of the decimal point, engineers have adopted a number of strategems. Electrical engineering is replete with examples of one of these—thus we have the *meg*ohm, the *kilo*watt, the *milli*volt, the *micro*ampere, etc. Another device, found frequently in tables and graphs, is the heading: $(\times 10^{-6})$. (For the tyro a factor of 10^{12} is at stake here!) This latter device has real merit when the user takes the trouble to be explicit. Employing it thus, we may write our "big number" as 3.0×10^{7} and our "little number" as 6.5×10^{-6}. This has obvious advantages on two counts: the necessity for counting zeros is gone, and the number of significant figures is unambiguous.

It is our purpose here to indicate a highly useful abridgement of this notation which also makes it compact. One simply writes

$$3.0\backslash^{7} \equiv 3.0 \times 10^{7},$$
$$6.5\backslash^{-6} \equiv 6.5 \times 10^{-6}.$$

The inventor of this notation seems to be Dr. L. B. Tuckerman,[3] who taught it to one of the authors (H. R. G.) at the University of Nebraska over 35 years ago. Both of the authors have presented it to many classes in engineering mathematics and mechanics over a period of years. Frequently this has been done merely by using it while working out

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[3] Until his recent retirement Dr. Tuckerman was associated for many years with the National Bureau of Standards.

illustrative examples at the blackboard (the notation has, of course, always been explained briefly at the time of initial use). We have found that students quickly comprehend this abbreviation and many adopt it for their own work. It has particular advantages in many slide rule operations. We consider a single example which is amply endowed with opportunities for decimal point error. In finding the tip deflection of a steel cantilever beam ($I = 82.5$ in.^{4}) of 30 foot span under a tip load of 1250 lb., one is led to the computation

$$\delta = \frac{PL^3}{3EI} = \frac{(1.25\backslash 3)(3.6\backslash 2)^3}{(3)(3\backslash 7)(8.25\backslash 1)} = 0.785\backslash 1$$
$$= 7.85 \text{ in.}$$

The location of the decimal point in the first form of the result is easily fixed by a rough mental calculation. The determination of the exponent of 10 is, of course, a simple application of the laws of exponents. The use of the convention is certainly no guarantee against decimal point errors in such computations, but experience shows that they are greatly reduced thereby.

Clearly the number of examples of the usefulness of the method could be multiplied *ad nauseam*, but no purpose would be served by this. The advantages, we believe, are apparent. We strongly urge its presentation to technical students, early in their academic careers.

College Notes

Massachusetts Institute of Technology and **Harvard University** today announced plans for a joint five-year program aimed at increasing the number of broadly trained science and mathematics teachers available to secondary schools. Under the new Harvard-M.I.T. curriculum, beginning next September, young men and women will be trained for science and mathematics teaching in high schools and junior colleges. Their course will lead to the degrees of Bachelor of Science in General Science at M.I.T. and Master of Arts in Teaching at nearby Harvard University. The undergraduate phase of the project is largely at M.I.T., although some Harvard courses may be taken as early as the third year. Thereafter, students will take courses at both institutions and draw on the educational resources of both. During the fifth year, students will teach part-time at local high schools, under the direction of the Faculty of the Harvard School of Education.

Seventy faculty members, largely from the Southern universities, are spending this summer on research projects in the **Oak Ridge** facilities of the **Atomic Energy Commission.** They are in Oak Ridge under the auspices of the Research Participation Program, a joint activity of the Oak Ridge Institute of Nuclear Studies and the Oak Ridge National Laboratory. The great majority will work in the extensive research facilities of the Oak Ridge National Laboratory, but others will be on duty with the Institute Medical Division and the University of Tennessee-AEC Agricultural Research Program. In addition to the 70 individuals who will be in Oak Ridge for the entire summer or longer, 96 participants will attend the three one-month courses in radioisotope techniques offered by the Special Training Division of the Institute this summer. An additional twenty will attend the Division's course in autoradiography, and several hundred are expected for the annual Oak Ridge Summer Symposium, devoted this year to "The Role of Engineering in Nuclear Energy Development." It will be held from August 27 to September 7.

New Members

ACTON, FRANK, J., Associate Professor of Mechanical Engineering, Tri-State College, Angola, Ind. J. G. Radeliffe, J. C. Humphries.

AHLBERG, CLARK D., Assistant Dean, Administrative Engineering, Syracuse University, Syracuse, N. Y. B. H. Norem, R. A. Galbraith.

AKESSON, NORMAN B., Lecturer, Agricultural Engineering, University of California, Davis, Calif. S. M. Henderson, L. Bamir.

ARTHUR, GEORGE R., Instructor in Electrical Engineering, Yale University, New Haven, Conn. A. G. Conrad, J. G. Clarke.

ATKINS, JACK W., Instructor in Engineering, Weber College, Ogden, Utah. M. L. Stevenson, J. E. Christiansen.

BAEUMLER, HOWARD WILLIAM, Instructor in Mathematics, University of Buffalo, Buffalo, N. Y. H. M. Gehman, R. E. Shaffer.

BARTHOLOMAEI, NATHANIEL T., Instructor in Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. E. McHugh, M. G. Mochel.

BENNETT, CARSON W., Librarian, Rose Polytechnic Institute, Terre Haute, Indiana. C. E. Kircher, Jr., R. K. Strong.

BLANCHARD, FLETCHER, A., JR., Instructor in Electrical Engineering, University of New Hampshire, Durham, N. H. E. H. Stolworthy, O. T. Zimmerman.

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BLUMENTHAL, IRWIN S., Instructor in Electrical Engineering, Yale University, New Haven, Conn. J. G. Clarke, A. G. Conrad.

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BURCHFIELD, GEORGE E., Instructor in Engineering Shop, General Motors Institute,, Flint, Mich. H. M. Dent, C. L. Fanning.

BURKE, DALE H., Tool Engineer, Production Engineering, Champion Spark Plug Co., Toledo, Ohio. W. F. Rohr, W. G. Rohr.

BYERS, EARLE C., Instructor in Shop Practice, Kansas State College, Manhattan, Kans. G. C. Timmons, G. A. Sellers.

CEBULA, RICHARD S., Instructor in Civil Engineering, St. Martin's College, Olympia, Wash. F. Kerekes, S. H. Fuller.

CHEDSEY, WM. R., Professor of Mining Engineering, University of Illinois, Urbana, Ill. H. L. Walker, F. M. Dawson.

CHERRY, LLOYD B., Professor and Head, Electrical Engineering Department, Lamar State College of Technology, Beaumont, Texas. E. R. Stapley, A. Naeter.

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CLARK, WILLIAM E., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. E. H. Stolworthy, E. T. Donovan.

COWLES, HAROLD A., Instructor in General Engineering, Iowa State College, Ames, Iowa. S. J. Chamberlin, M. B. Richardson.

CRAWFORD, JOHN H., Dean of Engineering, Merrimack College, Andover, Mass. S. Morehouse, J. J. Gallen.

CURRAN, BROTHER HENRY, Instructor in Engineering, St. Edward's University, Austin, Texas. B. E. Short, B. F. Treat.

DABNEY, WALTER M., Associate Professor of Civil Engineering, Tennessee A. & I. State College, Nashville, Tenn. D. E. Howard, E. R. Welch.

DANIELS, TED E., Project Engineer, Wind Division, Stewart-Warner Corporation, Indianapolis, Ind. W. W. Turner, C. P. Buck.

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DURHAM, DWIGHT W., Assistant Supervisor of College Relations Group, Personnel Div., E. I. duPont de Nemours Co., Wilmington, Dela. T. H. Chilton, G. O. Andrews.

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FLARITY, EARL C., Coordinator, Technical Training Div., Ind. Edu. Dept., Chrysler Corp., Detroit, Mich. D. C. Hunt, O. B. Norem.

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FREY, AUSTIN R., Chairman, Physics, U. S. Naval Postgraduate School, Annapolis, Md. F. M. Dawson, A. B. Bronwell.

GOODMAN, LOUIS J., Assistant Professor of Civil Engineering, Ohio State University, Columbus, Ohio. F. M. Mallett, K. W. Cosens.

GOODWIN, ERNEST B., Assistant Professor of Electrical Engineering, University of Rhode Island, Kingston, R. I. W. B. Hall, C. B. Clarke.

GOODWIN, WILLIAM A., Instructor in Civil Engineering, University of Kentucky, Lexington, Ky. F. J. Cheek, Jr., D. K. Blythe.

GREER, ROBERT W., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. R. J. Ungrodt, F. J. Van Zeeland.

GREIBER, CLARENCE L., State Director of Vocational and Adult Education, State Board of Voc. and Adult Education, Madison, Wis. E. C. Koerper, F. T. Agthe.

GUILD, LAWRENCE R., Professor and Head, Depts. of Management and Industrial Engineering, University of Southern California, Los Angeles, California. R. E. Vivian, L. R. Schruben.

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HAASE, HAROLD F., Associate Professor of Mechanical Engineering, Marquette University, Milwaukee, Wis. W. D. Bliss, J. E. Matar.

HALL, KEITH W., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. E. P. Vincent, F. Schwartz.

HOILMAN, CHARLES W., Associate Professor of Electrical Engineering, University of Vermont, Burlington, Vt. R. P. Mosher, E. R. McKee.

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HOSMER, W. T., Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa. R. Winfrey, L. O. Stewart.

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HUFFMAN, JOHN R., Assistant Professor of Industrial Engineering, University of Southern California, Los Angeles, Calif. R. E. Vivian, L. A. Schruben.

HULSBOS, C. L., Assistant Professor of Civil Engineering, Iowa State College, Ames, Iowa. R. Winfrey, L. O. Stewart.

IBATA, RALPH M., Assistant Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb. E. J. Ballard, O. E. Edison.

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KAPLAN, BERNARD, Instructor in Civil Engineering, City College of New York, New York, N. Y. W. Allan, W. L. Willig.

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KRAUSE, HENRY, Chairman, Engineering Drawing Dept., Bowling Green University, Bowling Green, Ohio. R. S. Paffenbarger, C. L. Brattin.

KUSKO, ALEXANDER, Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. K. L. Wildes, C. E. Tucker.

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LEPAGE, WILBUR R., Professor of Electrical Engineering, Syracuse University, Syracuse, N. Y. S. Seely, R. P. Lett.

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June 23–27, 1952

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Engineering Planning

By HAROLD S. OSBORNE

Chief Engineer, American Telephone and Telegraph Company

Last year in speaking to this group on the general question of engineering education and the requirements of industry, I remarked that the young engineer as he comes into industry generally has little conception of what is involved in carrying out the broad range of engineering studies which can be described as engineering planning. My assignment today is to enlarge on that remark and discuss the possible relation of engineering planning to the curriculum of the engineering school.

What is Engineering Planning?

It seems desirable first to outline what is meant in this discussion by the term "engineering planning." This seems particularly necessary because the word "planning" is very widely used, and even abused, in relation to a great deal of human activity in all fields of work.

Engineering plans are of many types. While no classification can be cleancut, I think it is helpful in our discussion to name and define a few distinctly different types.

First there is the type of plan which consists of detailed specifications of a specific object or a type of object to be constructed. Examples of this are the specification for an electric generator or the plans and specifications of a building. Following Mr. Chester Barnard's terminology I will call this the "explicit" plan.

Young graduates of engineering schools are generally familiar with this type of plan—it is closely related to their college work and they have an appreciation of the need for it and the problems involved.

The next classification we will call the "project" plan. It relates to a complex of jobs which are involved in one project and to the inter-relations between these parts of the project. It often includes a number of explicit plans.

An illustration of the project plan which is common in the telephone field is the replacement of a manual central office with a dial central office. This often involves the selection and purchase of a site, the design and construction of a building designed to meet the special technical needs of the case, the selection of the type of dial central office equipment to be used, the specification in detail of the quantities, types and interconnection of a large variety of equipment units, the design of the floor plan layout, arrangements for the provision of power including usually both commercial power and an emergency engine driven generator set, the design and installation of conduits and telephone cables to connect to the new equipment the telephone lines which are to be served, the changing of telephone sets or the installation of dials for all customers of the area, the instruction of customers in the new method of operation, the issuance of a new directory, provision for the future of operators who no longer will be needed at this location after the change to dial operation, and the employment and training of the additional

* Presented before a joint meeting of the Electrical Engineering and Industrial Engineering Division at the ASEE Annual Meeting, East Lansing, Michigan, June 26, 1951.

men necessary to carry out the work involved in the project and to maintain the new building and equipment in normal service. Very often a project includes also the provision of new means for handling toll messages and new terminations for toll lines. Underlying and preceding all of this work are the necessary studies to determine that the project is a desirable one from the standpoint of service, economy and the general development of the telephone system in that area, the best general location of the proposed new office and the time when the job should be done.

This project includes a considerable number of interrelated explicit plans. It involves an intimate correlation between all of these explicit plans to form an organic whole. When the project is carried out it involves also a close coordination of timing of a wide variety of jobs done by different groups of people.

Illustrations of the project plan could be multiplied in all fields of engineering work.

A third type of plan may be called the fundamental plan. This type of plan is more far-reaching and forward-looking than the project plan and correspondingly far less explicit. It expresses the best picture which can be prepared at this time of the future design of a plant or operating system. It is intended to crystallize the goal toward which current projects should be directed and to be used as a base of reference in the design of all such projects. It is often of great importance in determining the future adequacy and financial health of the entire enterprise.

An illustration of a fundamental plan is given in a paper presented last January at the A.I.E.E. Winter Meeting by several engineers of the American Gas and Electric Service Corporation. This paper described the proposed 315-kilovolt transmission system of the American Gas and Electric Company. Looking forward it was recognized that the present 132-kilovolt network in Ohio, Indiana, and adjacent states would become inadequate. Extensive researches in the economies and problems of the use of higher voltages led to the selection of 315 kilovolts as the best level for the new transmission system. Plans were then made of the points which should be interconnected by the new high voltage system, the tower and conductor design, number of circuits on each route, interconnection with the rest of the system and all of the general features of this great project. This plan will serve as a guide in the design of the future transmission line projects of this power system.

Another illustration of a fundamental plan is the nationwide toll dialing plan adopted recently by the Bell Telephone Companies. Toll dialing is the method of operation by which a toll call is completed by mechanical means directly to the called telephone in the distant city without the assistance of operators at the distant city or at intermediate points. The electrical impulses which control the switches at remote switching points may be originated by an operator at the originating point, or directly by the customer by twirling his dial.

Toll dialing has long been used in various parts of the country on a regional basis. A number of years ago we initiated studies to determine whether the results achieved by the operation of these regional networks and the possibilities of further technical developments made it desirable to plan for the indefinite extension of these forms of operation in one nation-wide interconnected network. Such a decision was made and a plan developed which affects all future development of toll telephone installations throughout the country.

The plan involved the adoption of a new principle, namely, that the digits transmitted into the machine for completing a toll call would designate only the destination of the call and not the route to be followed in reaching it—the route to be determined by the machine.

This made necessary the development of automatic switching machinery with greater powers of selection and direction of routing than had been produced heretofore.

The extension of customer dialing depends upon further technical developments. New forms of machinery are necessary to record automatically all the information required for billing the calls.

The plan involves major revisions of the general toll switching plan previously used by the Bell Telephone Companies. The new toll switching plan concentrates the new and complicated forms of equipment at a relatively small number of carefully selected points.

The plan involves development of radically new trunking plans, taking advantage of the ability of the machine to test rapidly a number of alternative routes if the route first selected has all circuits busy.

The plan involves the development of a non-conflicting system of telephone numbers covering the entire area of the United States and Canada. Any telephone in this area will be uniquely designated for toll dialing purposes by ten digits. These must be related closely to the local telephone number. The problem of meeting these two requirements without conflicts is one of great complexity.

I wish I could convey to you in a few words the fascination of work on this important and far-reaching plan. It will provide gradually for a marked and general improvement of long distance telephone service throughout the country. It will be a basic guide in the investment of hundreds of millions of dollars in the construction of toll plant. It establishes requirements for telephone equipment which direct years of development work in this field. It constitutes a major creative effort on the part of a large number of engineers throughout the country who have taken part in the vast amount of work involved.

While I have mentioned only two fundamental plans, engineering work abounds with other illustrations. Probably too there are many situations where a fundamental plan is needed and not made because of the preoccupation or limited horizon of those who would be responsible for such work.

A fourth type of engineering plan which should be mentioned can be described as a program. The project plan does not of itself inherently include any schedule of the times at which various parts of the plan will be carried out. Such a program, however, carefully coordinated, is necessary for the execution of the project. A fundamental plan is usually too forward-looking to be covered by a single program, but programs are prepared from time to time covering expected activity for a few years ahead. These programs are important to coordinate various projects for satisfactory development along the lines of the fundamental plan. The preparation of programs, therefore, while often associated with a project plan or a fundamental plan, is an independent act of planning.

Within my experience, engineering graduates are often aware in a general way of project plans and familiar with plans described in current literature. They are usually quite unaware of the scope and variety of the work involved and of the problems of coordination and evaluation necessary in arriving at the decisions which must be made in such planning work. They are likely to have no conception whatever of the fundamental plan. They do not have an appreciation of the importance of this type of planning in engineering work.

The Principles of Engineering Planning

I do not suggest that the student might be trained in his undergraduate work to be competent in engineering planning. Engineering planning is an advanced subject—one of the highest forms of engineering activity. Accomplishment in this field depends upon a creative imagination born of the union of natural ability and experience. All that we need to consider here is whether anything more

can be done than is now being done in the crowded years of the curriculum to train the young engineer in the techniques and principles which he will later apply in planning work and to give him an appreciation of the scope, amount and importance of this type of work in his future professional life.

There are certain techniques which are important in engineering planning, on which it seems to me more emphasis could advantageously be placed. Of first importance among these techniques I place those of engineering economy. This subject enters in an important way in all engineering planning as well as in other engineering work. I don't think that the young engineer is fully trained for professional work unless he is thoroughly familiar with the principles of engineering economy.

Another technique which applies to engineering planning work is that relating to precision. The inexperienced engineer working on an engineering plan may spend vast amounts of time and effort in working out degrees of detail which are not significant. In such a plan the engineer is dealing with the future with all of the uncertainties which that term represents. He must determine what are the most significant variables in his problem, what are the probable degrees of variation and what effect these have on the outcome of his study. I would say that because of considerations of precision a forward-looking study generally should include only those details which it is necessary or important to determine upon at the time. All other details should be left for further development by explicit plans made at the time action is taken on each part of the over-all plan.

The ability of the young engineer to apply to a planning project the principles of precision as above outlined certainly is helped by his knowing the principles of elementary statistics particularly of sampling and of the precision of results.

Engineering planning involves the use, consciously or unconsciously, of the principles of logic. The planning work should be inclusive—no alternative completely overlooked. There are historic cases where tremendous amounts of engineering effort were done unnecessarily because the work was started along the wrong lines. In practice, to be able to consider all alternatives requires ability in classification and comparison, so that the less favorable possibilities can be rejected by classes or groups rather than individually.

Througout the planning work it is necessary accurately to present and to judge comparisons of alternatives. These comparisons often involve quite dissimilar conditions and the inclusion of both tangible and intangible factors. To sum these up so that the correct decisions can be made at each point as the work proceeds is an important part of the technique of engineering planning.

Planning in Relation to the Curriculum

In approaching the question of what relation the subject of engineering planning has and should have to the curriculum of the engineering school, I have discussed the matter with 26 of the more recent engineering graduates in my own department. These men come from 20 engineering schools all over the country.

The men were unanimous in the opinion that it is important for the graduate to have an appreciation of engineering planning and nearly unanimous in believing that an effort should be made to get more of this training into the curriculum. Most of them recalled elements in their courses which they now recognize as training in planning, but consider that more could well be done.

As regards specific techniques which might be made a part of the curriculum, the most concrete item I have to suggest is engineering economy. Here is a considerable body of technical principles which are teachable. I have already expressed my opinion that these principles should be included in every

engineering course. The same thing can be said regarding the techniques which relate to determining the precision of results, the size of samples and similar elementary statistical methods.

In addition there is a considerable body of principle which relates to planning work. Some of this I have briefly suggested in this discussion. It might be called "Applications of Logic." While this theoretically might be the subject of a course, I am not suggesting that it be added to the curriculum. I have not seen any text which develops these principles in the tangible form necessary to make them attractive for use in engineering school courses.

Without adding any subjects to the curriculum, however, it would appear that there is great advantage in including planning problems and a discussion of planning methods in the present subjects of the curriculum to the extent this is practicable. This type of work is an excellent method of teaching the student to think, the basic aim of education.

An important opportunity to include planning work in the curriculum is presented by the laboratory exercise where the student is required to plan his own experiment in detail before going into the laboratory rather than being given instructions which he is to follow. I am strongly of the opinion that one laboratory experiment which the student has been required to plan completely himself is of greater value to him than two experiments in which he follows instructions.

In a few cases the young graduates whom I consulted referred to projects of a planning nature carried out by a group of students. In one case an entire summer course was devoted to this type of group planning. In several cases projects of a smaller nature planned by individuals or small groups were included in the regular winter work.

The more complicated forms of planning to which I have referred are necessarily beyond the scope of the student activities. There would appear to be advantage in giving the student as much appreciation of this work as possible. It would seem that seminars and lectures by men engaged in engineering practice could be so directed that they would bring to the student a great deal of appreciation of planning processes. To do this, however, would undoubtedly require a careful steering by the faculty of the subject matter and form of presentation. It might require that the presentation by the outside engineer be supplemented by discussions of the project by a professor who is skilled in analyzing the elements of the planning process.

Conclusion

The analysis which I have tried to bring to you can be summed up in four points:

1. The processes of engineering planning, particularly, of what I have called project planning and fundamental planning, are of wide and increasing importance in engineering work. It is advantageous to the young engineer to have an appreciation of the importance and scope of such work and to have as much training in the techniques which he will use in planning work as is practicable within the limits of the college years.

2. Certain techniques are important in engineering planning and other engineering work and should be a general part of the curriculum of the engineering school. Outstanding among these is engineering economy.

3. Teaching the student to think clearly and logically is the best preparation for work in engineering planning as well as other engineering work. The inclusion in the curriculum of simple planning problems would appear to be excellent training in this direction.

4. It should be possible to give the student an increased appreciation of what is involved in practical engineering planning work by directing to this subject seminars and outside lectures. Such direction would increase their value to the student.

Research and Development: The Nation's Balance Sheet in June 1951*

By ERIC A. WALKER

Dean of Engineering, Pennsylvania State College; formerly Executive Secretary, Research and Development Board

The Pentagon, designed to accommodate 18,000 people, is now straining at the seams with 32,000. Whether this is good or bad it is a small example of the pressure the national defense effort is exerting everywhere—not only upon our manpower and material resources but on the ability of the people to pay for it. We in the Defense Department are fully aware of this. We feel a keen sense of responsibility in our expenditure of the funds and manpower necessary to keep our defensive capabilities at a safe level. The magnitude of our task is illustrated by the fact that *military* research and development in 1951 costs more than seven times the amount of money expended on our entire *national* research and development effort in 1940. In my remarks concerning the nation's research and development balance sheet—and I am using the term "balance sheet" in its broad sense—I shall tell you something of the amounts of money we are spending and how they are being used, the factors contributing to the increased costs of research and development, the current technical and scientific personnel shortage and measures for relieving this, and the position and problems of the Research and Development Board. As a point of departure, I shall first compare research and development expenditures, both national and military, during the 1940–1950 period.

In 1940 the total *national* expenditure was about $350,000,000, while that of the *military* was in the neighborhood of $22,000,000. In other words, the military expenditure amounted to one fifteenth of the total national research effort. As of 1945, the national expenditure had increased to 1.1 billion dollars and the military expenditure—including that of the Office of Scientific Research and Development—had increased to $600,000,000. This military research figure was about one-half of the national total. During the five years preceding the outbreak of hostilities in Korea the military research and development budget, exclusive of atomic energy, remained more or less constant with an annual expenditure of around $500,000,000; but the increased international unrest after June 1950 was instrumental in more than doubling this. One estimate places the current national research and development expenditure at 1.75 billion dollars and another sees it as a total of 2.3 billion. Our military research and development effort now absorbs 1.1 billion dollars, with a further increase of about $200,000,000 expected in 1952. The 1.1 billion is apportioned roughly: $3,000,000 for work done in government laboratories, $650,000,000 for project contracts with industrial installations, and $100,000,000 for research conducted by colleges and universities. It is difficult to achieve any adequate measure of

* Presented before the ECRC at a general session of the society at the Annual Meeting, East Lansing, Michigan, June 26, 1951.

the expenditures *associated* with research and development, for the development eventually becomes testing and this is not paid for out of research and development funds.

Consider for a moment the effects of the budget increases. For one thing, we can expect that a large portion will be absorbed by rising costs. The Secretary of Defense recently stated that inflation has, in the past year alone, effectively taken from the military establishment about 7 billion dollars of the 35 billion voted to it by Congress. This inflationary trend has also been felt in the sphere of research and development.

A number of factors have contributed to the increased cost of research and development. As of December 1950, materials and service costs have gone up 19 per cent from the 1947 level and these are still rising. The salaries of employees under federal civil service increased about 13 per cent during the same period, and it is reasonable to suppose that there has been a comparable rise in those paid by industry and academic institutions. At present, the yearly cost of maintaining a scientist or engineer in a laboratory varies considerably even within the government. Approximations of such costs are: $26,000 for the Department of Defense and other government agencies (except the Atomic Energy Commission, where this expenditure runs to $30,000), $23,000 for industry, and $8000 for universities. These differences are a result in part of different definitions of a "scientist or engineer," but they also reflect variations in the cost of the equipment used and the amount of service help supplied the scientist by his organization. These constitute sizable increases over such costs even six months ago. Then there is the matter of overtime pay, necessitated by the current world situation, which will probably account for an additional 10 per cent increase in the cost of the research program. As a general thing, the type of research we are conducting requires very expensive equipment and facilities, such as large wind tunnels, high-speed electronic computers, and guided missile test ranges. Since most of these have no industrial application it is necessary that they be constructed and operated at government expense.

Engineering Manpower

I turn now to the problem of manpower, which I realize is a question of particular interest to this audience. One of our major difficulties at present is the acute shortage of engineers and scientists, particularly those trained for research work. The nation's scientific and technical manpower resources now total some 575,000 persons, of whom an estimated 25 per cent are equipped to do research. The 25 per cent figure represents roughly 130,000 research people, of whom about 25,000 are employed full time by the government, 70,000 by industry, and 35,000 by colleges and universities. The total number of engineers and scientists now required for the Department of Defense research program of 1.1 billion rounds out to 56,000, or 43 per cent of the total national supply. It is expected that in 1952 this percentage will rise to 52, with a total requirement for 68,000 technically trained personnel. If the research-personnel requirements of the Atomic Energy Commission and other agencies engaged in defense research are included, the requirement reaches a staggering 65 per cent.

The breadth of this military research effort is sobering as well as startling. We are confronted with the fact that a tremendous proportion of our scientific resources are being utilized for research on weapons, counter-measures, and techniques of warfare, and this must of necessity have a profound effect on our way of life. If we are to maintain a military research and development program and also provide for increased civilian research needs we must be sure that we are using our manpower as efficiently as possible. There have already been dis-

ruptions and dislocations in the fields of teaching and of academic and industrial research. In addition, we run the risk of lowering our national standard of living, of which we are justifiably proud, through the diversion of our scientific research and development effort from civilian consumer goods to materials with which to meet military requirements. This could affect the morale of our people adversely, with consequent impairment of our military machine. We must also beware of a condition in which basic research, the life blood of scientific progress, becomes excessively subordinated to applied research. Here, of course, it is encouraging to note that the picture has been brightened considerably by the formulation of a policy for military support of such research—namely that the Departments should budget no less than 6 per cent of their total annual research and development funds for basic research—and by the recent establishment of the National Science Foundation.

I should not like to give you the impression, however, that all of the money and manpower expended upon military research leads only to destruction of life, health, and property with the attendant human misery. Such research, however deadly its intent, almost always produces something with a constructive application. Chemical and biological warfare, potentially deadly weapons, have made important contributions to the medical and veterinary sciences. Studies of the action of nitrogen mustards, developed as toxic chemical warfare agents, have revealed the destructive effect of these mustards on white blood corpuscles. This finding suggests their use in treatment of leukemia and has led to such employment. Experiments with rinderpest, one of the most fatal animal diseases, have produced significant advances in the development of an effective vaccine against this disease.

Many manufacturing techniques used in the production of television tubes have resulted from research on cathode ray tubes used in radar. Military experimentation was responsible for a more ruggedized picture tube capable of maximum production in terms of quality and quantity. The technique used in sending television images from one station to another by radio links owes much to the microwave relay links and equipments developed for the armed services during the last war.

The airborne magnetometer, developed to aid in the detection of submarines, has proved a very efficient tool for geophysical prospecting for valuable minerals and for the determining of geological structures.

These few examples should serve to remind you that while we in military research and development are sowing dragon's teeth we are also sowing good seeds which are already yielding a harvest.

The great problem which confronts us at present is how to meet greatly increased demands without making wholesale inroads into the scientific staffs and faculties of our industries and schools. It is universally agreed that to make such inroads would be to court disaster. But where are the additional people we need going to come from? This is a question to which some of you gentlemen may have an answer. It is certainly one that we all must think about very seriously.

Declining Enrollments

Another critical aspect of the overall problem is the fact that while our military research and development requirements have been increasing at such a rapid pace, the number of college graduates in the scientific and engineering fields has decreased almost comparably. The fall-off in engineering college enrollments is particularly serious. According to the most recent figures I have seen, our colleges produced some 50,000 engineering graduates in 1950. This year will see a decrease to 38,000, and by 1954 the total is expected to be 18,000. Dr. James R. Killian has recently estimated the

number of 1954 engineering graduates to be as low as 12,000. Either of these figures would leave us considerably short of filling even the normal peacetime replacement need, and our demands have, of course, been greatly increased during the past year or so. I am reasonably sure that this shortage is also characteristic of scientific and technical fields other than engineering; and it cannot be alleviated in any short period of time. The situation will probably be even more acute 10 or 12 years from now, since an over-all decrease of 10 per cent in the number of high school graduates is expected between 1950 and 1958.

The explanation for this appalling shortage of scientific and engineering college graduates is not simple. The situation is no doubt partially attributable to the decreasing numbers of capable science teachers in our high schools, for it is these people who either stimulate or fail to encourage the desire for higher education in the scientific fields. A short-sighted view held by some engineering college administrators and faculty members a few years back may also be blamed in part. There was, as you all must remember, a widespread tendency to discourage prospective enrollees on the grounds that the employment market for engineers was in danger of being glutted! This view was probably based on figures contained in a report entitled *Employment Outlook for Engineers*, released by the Bureau of Labor Statistics of the Department of Labor. Although the completed report was not released until the late spring of 1949, much of the material was available previously.

Another complicating factor at the present time is the extension of selective service. A recent policy change has been effected whereby college students, through maintaining exceptional grades or passing a written examination prepared by Selective Service, may be deferred pending completion of their education, but it is too soon to determine how effective this will be. An unidentified student, commenting on the draft-deferment test, remarked that the Army is going to get a bunch of art students and psychologists if the test is used. If this young man is right we who are concerned with research and development will rest more easily, but I don't think it would be wise to count on it.

In addition to the demands of selective service, departmental call-ups of scientific reserve officers, particularly electronics specialists, are cutting into civilian scientific activities.

The ultilization of scientific and technical personnel within the Department of Defense is yet another aspect of the problem. The Office of the Assistant Secretary of Defense for Manpower is working on a policy for the most effective assignment of scientists and other specialists to military jobs. If adopted, this policy will help to prevent waste of scientific manpower acquired by the services.

There are certainly no ready solutions to the technical-manpower problem. The stepped-up defense program requires additional personnel, and it is clear that to a great extent these can be obtained only at the expense of other research and development activities. If there is unreasonable competition between various agencie for needed personnel, additional fuel will be piled on the fires of inflation and our research and development dollar will buy less and less.

Since I don't want to sound like the definition of a pessimist that I heard recently—a person who must appear unhappy in order to be happy—I should tell you that there are some promising aspects to the situation. As I said before, only about 20 per cent of our trained engineers and scientists are actively engaged in research and development, but ways are being explored whereby the use of the national reservoir of technical personnel can be maximized.

Engineering Manpower and Military Service

The Buckley Committee, a staff agency under the chairmanship of Dr. Oliver E.

Buckley, Chairman of the Board of Bell Telephone Laboratories, has recently been organized to advise Defense Mobilization Director Charles E. Wilson regarding coordination of government and private scientific research and planning for defense. One of the problems which it will consider is the availability of scientific manpower. The membership of this group includes William Webster, Chairman of the Research and Development Board; Dr. J. Robert Oppenheimer, Director of the Institute for Advanced Study, Princeton University; Dr. Hugh L. Dryden, Director of Aeronautical Research, National Advisory Committee for Aeronautics; Dr. Detlev W. Bronk, President of Johns Hopkins University; Dr. Alan T. Waterman, Director of the National Science Foundation; Dr. James B. Conant, President of Harvard University; Dr. Lee DuBridge, President of California Institute of Technology; Dr. James R. Killian, President of MIT; Dr. Robert F. Loeb, of Columbia University's college of physicians and surgeons; Dr. Charles A. Thomas, Executive Vice President of the Monsanto Chemical Company.

Problems dealing with the scientific-manpower shortage give rise to the question of some sort of national scientific service, however, and this is part of the over-all manpower problem, which certainly cannot be solved overnight. In line with this, the American Association for the Advancement of Science recently approved a resolution stating in part

> . . . a system of Universal *National* Service, as distinct from Universal *Military* Service, should be instituted, to be administered by a carefully qualified civilian agency that will grant no deferments but will allocate all scientific and technical personnel to such national service as their individual training and skills permit, and national needs require.

It should be added that a number of academic institutions are also offering assistance in the solution of the manpower problem. To meet the nation's needs for a greater number of broadly trained engineers, several schools of engineering have recently entered into agreements with liberal arts colleges to offer students a combined five-year program leading to both a B.A. and B.S. degree. Under the program, students spend three years in the colloge of their choice, taking a liberal arts course. Upon recommendation of the liberal arts school, they will then be accepted by the engineering schools for two years of specialized engineering training. At the completion of the entire program they will receive two degrees.

Another partial solution that is receiving consideration is the full utilization of the scientific resources of our allies. I believe that something of this sort is being done through the London Office of the Office of Naval Research and through certain State Department scientific-liaison agencies. It may soon be formalized by agreements between the NATO countries. There is already a considerable exchange of scientific information between the United States, the United Kingdom, and Canada and it may also be possible to make use of the expanded research effort in certain Latin-American countries which is now receiving support under the Point IV program.

Military Research Program

After this statement on the over-all budget and manpower situation, and the attendant problems, you are probably wondering about the organization of the military research and development program. One of the questions we are often asked is, "Is there going to be another organization of the OSRD type?" I cannot say positively that there will be no such organization, but I can tell you that none is contemplated at present. The research programs of the services are more complete than they were at the time when the OSRD was in operation; also, more scientists are actively employed in the program and more advice is sought from outside scientists. Thus the combined

research and development program encompasses the types of activities carried on by OSRD. The services now administer their own research and development, which is carried out in government laboratories or by contract with industrial organizations or universities. The programs are guided and constantly reviewed by the Research and Development Board.

Before I tell you what the RDB is and how it functions, perhaps I should tell you what it is *not*. It is not an operating agency; and by that I mean that it does not let contracts or administer research and development programs. It serves, rather, in an advisory capacity; the details of carrying the programs out are left to the military departments. This division of responsibility is carefully delineated in our directive, which states: "The Board shall not direct or control the internal administration of the research and development activities and programs of the several departments and agencies of the Department of Defense." In addition to program guidance, our specific duties include the review of departmental budget estimates, review of facilities proposals, advising the Secretary of Defense on obligation of funds, preparation of estimates of the technical capability of weapons and countermeasures for consideration by the Joint Chiefs of Staff, and elimination of undesirable duplication.

Besides the seven-man Board, composed of a civilian chairman and two members from each of the military departments, there are a number of committees which correlate work done in their respective fields and advise the Board and the Departments accordingly. These Committees, of which there are 14 at present, cover such subjects as atomic energy, chemical and biological warfare, and guided missiles. They are assisted by full-time secretariats, and by panels, subpanels, and working groups. Since the committees and their subgroups are composed of experts from industry, universities, and the military departments and other government agencies, they assist also in bringing about a fruitful cross-exchange of information. The largest committees at present are Aeronautics, Electronics, Guided Missiles, and Ordnance.

We believe that we have contributed a great deal to the integration of the various military research and development programs and to the over-all program as well. We are faced, however, with a number of basic problems which make our task more difficult and, I fear, prevent the research and development program from attaining the effectiveness which we would like to see.

One of the Board's most urgent problems is the need to find a qualitative measure of the research and development program. The popular tendency, which I think is a fallacious one, is to measure the quality of research in terms of expenditures and numbers of people employed. This carries over into civilian scientific endeavors as well. For example, there seems to be a feeling that if 100 million dollars are spent on cancer research, the return will be 100 times what would have been achieved had only one million been spent. Any scientist knows, however, that this is not necessarily true. The ratio between heavy expenditures and probable success in solving the problem is a favorable one generally, but it is not infallible. Such things as expenditures and numbers of personnel cannot, therefore, be accepted as measures of accomplishment. They merely indicate the use to which the nation's financial and manpower resources are being put.

At present the Research and Development Board has cognizance over approximately 8500 research projects which range all the way from improved shipping containers to a guided missile with a 5000-mile range. It is, of course, necessary to concentrate on development of some of these projects at the expense of others; so we must continually ask our-

selves and others the questions: How important is the problem? How valuable is the result of our effort in this direction going to be? The answers to these can't be arrived at simply; we run into a great deal of conflicting opinion which makes difficult the assessment of relative importance and probable return.

Evaluation Methods

In industry one can approach the probable return by estimating the net profits which might be expected to accrue from a product under development. In war, however, success is not measured by so simple a yardstick. It is measured, rather, by numbers of enemy dead or incapacitated, by numbers of our people *not* dead or injured, or by territorial gains, and our weapons are developed in accordance with what we think these would be. On the other hand, just to complicate matters still further, the most valuable weapon which could be developed would be one which would deter prospective enemies from aggression, rather than decimate their armies or civilian populations. Military history for centuries demonstrated that for every offense a defense could be developed, but the possibilities inherent in such weapons as the super-atomic bombs are so frightful that the possession of sizable numbers of them by any nation would give would-be aggressors grounds for serious consideration.

To take a hypothetical example, suppose that a cosmic ray capable of destroying all life within a radius of 100 miles could be developed. How would you measure the value of this in dollars and cents? Could you say that the research on it would be worth 100 million dollars—or one million? So you see that first of all we need a set of measurements for determining the value of projects.

The first thing that needs to be done in evolving such a set of measurements is to determine the relative importance of the various types of operations. Are land operations more important than strategic bombing? Are amphibious operations of more value than biological warfare? What is the relative importance of guided missiles and electronic communications systems? In these large areas the answers are subject to endless debate. One can estimate the relative effectiveness of modes of warfare only by approaching them in terms of specific weapons systems and individual weapons.

The second need is for a method of evaluating the probable success of a given research project. The most revolutionary idea is of no use if it can be proved impossible to develop and apply, or if its development and application would be too costly in terms of dollars and man hours. But again, the difficulties of accurate assessment intrude. It is obvious, however, that once we can determine the importance of a problem and the probability of solving it we shall have two important criteria for our measurement of a research and development program.

A third point which requires consideration is the efficiency with which a research program is being conducted, on both the administrative and working level. No two teams of researchers are equal in talent; nor do the teams have the same backgrounds, facilities, and supporting staffs. If we could obtain some workable measure of efficiency of research groups we could weed out the inefficient ones and foster the qualities which make others successful. Individual laboratory directors can often find a relative standard for judging the productivity of their workers, but officials who coordinate the work of people in widely separated laboratories where they have slight acquaintance, if any, with the workers have quite a difficult time. This difficulty is magnified when a research coordinator or contract administrator is trying to decide whether a certain project should be put into the hands of a government laboratory, an industrial organization, or an university.

Administrative Problems of Government

One of the great problems that besets government research administrators lies in the fact that, without personal standards for measuring the difficulty of problems or the efficiency of their research teams, they must make administrative and scientific decisions involving the expenditure of millions of dollars. Also the current personnel shortages sometimes necessitate the use, as administrators, of persons with little experience in such lines. Here the government deviates sharply from industrial practices, since most industries go to great lengths to procure the services of outstanding administrators, who are paid several times the amount their counterparts in government receive for administering many times the same volume of research. The net result of this is that government research, even when carried on by industrial installations, is often done with much lower returns than that conducted by industry directly.

Another problem confronting those who guide government research is the question of when to consider a project finished and stop work on it. A research director plans a program for solving a given problem and estimates the time and money which will be required. At the end of that time the problem may not be solved, usually because of difficulties which cannot be identified. There may have been unforeseen technical obstacles or the assigned staff may have been incompetent. At any rate, the question arises: What should be done? Should the project be continued or cancelled? How imminent is the solution? Those doing the work nearly always want the program continued, and this feeling is apt to carry over to the research director. The end result is that sometimes programs which ought to have been cancelled long ago drag along, absorbing money and manpower that could be used to much greater advantage somewhere else.

A problem equally important and equally difficult is the question of when the research phase should be terminated and the device put into production. Rarely is a research man satisfied with the results of his work. He can always see how the device can be improved, made more efficient and more reliable, and at times (one feels) more complicated. Many difficulties arise in deciding whether the original problem has been solved to the extent where a production line can be set up. The OSRD encountered this problem in World War II and solved it in a reasonably satisfactory way by establishing the Engineering and Transition Office. This Office was staffed by people who understood military requirements and, where these existed, the specifications for the completed device. They also understood the working of the prototypes constructed by the researchers. Lastly they had some comprehension of manufacturing processes and materials; so, from this collection of information, they were able to decide when the item should be put into production. The military services now have evaluation groups to which the making of such decisions is entrusted.

In closing I should tell you that the over-all military research and development picture is quite a promising one; although, as I have indicated, there are some spots which need touching up. It was inevitable that in the sudden huge expansion of the program certain problems should arise; but these problems are widely recognized by the military departments and other government agencies, and all possible steps toward their solution are being taken. We have been successful in developing greatly improved weapons. Two additional positive results are the new sense of awareness of the importance of technology to modern warfare and a mutual respect between the military and the scientists.

Engineering Manpower for Industry*

By DON G. MITCHELL

President, Sylvania Electric Products Inc., New York, N. Y.

It would be presumptuous of me to offer you any statistics on the engineering manpower situation. I am sure you must know by heart how many engineers were graduated last year and this year, and how many are in each of the classes now in college. You know how representatives of industry have swarmed on your campuses desperately trying to sign up some engineers at attractive starting rates.

It would be my guess that this year not one of you has had the spectre of unemployed seniors to plague you. Every graduate either has been placed or can be placed, once he makes up his mind which bid he will accept. Aside from the fact that some of these young men will not return from their tour of duty with the Armed Forces, it must be a comfortable feeling for you to know that as you start on the finishing of next year's model none of the last is left over in stock.

It is not as comfortable for industry. As you well know, there are not enough engineers to go around.

Defense Requires Engineers

We are trying to maintain a civilian economy at the same time that national defense requirements are increasing and use of critical materials is being restricted. This is a problem that needs engineers and more engineers, but the defense services also need engineers.

This isn't anything new. We have had national emergencies before. When shortages developed we either learned how to get along with what we had or we turned to some substitute source. Sometimes the necessity has brought practices that have been beneficial long after the emergency has passed. Such a situation could develop in the employment of engineering manpower.

Perhaps we can draw some comparisons between engineering and some of the skilled trades. At one time a machinist had to spend six or seven years learning his trade. When he became a journeyman he could make up the work and operate any machine tool. Mass production industry, however, couldn't wait as long as that to train machine mechanics. Men were trained for special work in a fraction of the time it took for the overall training.

Welding is another skilled trade that takes a lot of training to learn all the tricks of the trade. During the last war women were trained for special work in a matter of weeks.

Training Wasted

It seems to me that we have been giving thousands and thousands of young men a four year training in the fundamentals of engineering, at considerable expense to them, and then putting a great many of them in jobs that could be done as well by people with a fraction of the training.

For a long time, engineers were poorly paid by comparison with college trained men in other professions. Supply and demand had, of course, more than a little to do with it, but an important factor

* Read at Annual Convention, American Society for Engineering Education, East Lansing, Mich., June 28, 1951.

was the type of work they were doing. Even so, I am none too sure that industry did not pay more to engineers for doing that kind of work than it would have had to pay to non-college trained people.

How many engineers are hunched up over a drafting board on mechanical work? How many are compiling statistics and drawing graphs? How many are playing nurse to ailing machines? How many are making routine tests? How many are caught in blind alleys doing specialized work that requires no particular talent?

In other words, do we have a shortage of engineers or does it just look that way because of the manner in which we have put engineers to work?

Would we have a shortage of engineers if we replaced them with people trained to do some of these routine jobs on which engineers are now being used?

Obviously, I am speaking generally because, of course, there are many men who succeed in getting an engineering degree who will never be able to go beyond routine work. People so mentally limited would probably enjoy life more if they never had gone to college.

If what I am suggesting could happen, actually does come to pass, I believe that industry, engineers and education will all benefit.

Reevaluation of Formal Training

Let me ask you, who do the original selecting and the basic training, if it is fair to leave the responsibility for ultimate determination of an engineer's employment entirely to industry? That, I know, is an academic question and we could argue it all night long and get nowhere. Nevertheless, I think you will agree that industry has a point when it says that every time it is saddled with a frustrated individual it acquires a possible point of social infection.

Probably the greatest gain would come through a reevaluation of the formal training of engineers in the light of what industry really wanted. This is a subject which has been discussed so much that there should be little left to say. Nevertheless, I am sure that if industry finds it can fill advantageously the routine jobs with people who are not engineering graduates, our engineering schools and industry will find it necessary to reappraise the quality of the formal training.

Just why do we need engineers in industry? One could answer by enumerating the different kinds of jobs in which engineers are employed, which is what industry does in its recruiting college work. If what I have been saying, however, has any validity this approach would offer us no constructive solution to the problem of engineering manpower adequacy. Instead, I am going to discuss the larger aspect of our need.

Sound National Defense Needed

Of first importance today is the creation of a sound national defense that will protect us and the other free nations of the world from the spread of aggression by Communist countries. Without the United States the rest of the world is doomed. Europe is too weak from the last war to resist. Asia has no defenses worth mentioning, nor has South America.

What do we have that makes us so sure of ourselves? It isn't our natural resources of metals, fuels, forest, soil and water, for the opposition has these in abundance and, as we deplete our own reserves, we find ourselves more and more dependent on others.

Nor is it our population of one hundred and fifty million people. The nations within the Russian orbit greatly outnumber in population the peoples of the free nations.

We Excel in Productivity

Our physical superiority lies in our creative and productive abilities—broadly in the field of engineering.

The United States has two things which have defied competition from the

rest of the world—two things which we call by different names but which are as inseparable as Siamese twins. I refer to our worker productivity and to our standard of living. Without a high productivity there could be no high standard of living and without the latter there would be no reason or excuse for the former.

However, this can be no hare and tortoise race. Once you are out in front you must stay in the lead. With the manpower and the resources that the Russian controlled countries have, any time they get in front they win the race. Not only must we stay in front but by the same relative margin, in order to make up for any superiority in numbers and natural resources they have.

Russia Respects U. S. Production

Russia has a great respect for this margin. For some time she has been testing it anew to find out the actual superiority of productivity over sheer numbers. At one time this year the reported losses in Korea gave the ratio as 100 to 1. Perhaps Russia will try out other combinations to learn whether or not there is a ratio that will warrant an all out war on her part. What that is, of course, I do not know but I am confident that today we have the superiority that will win if a showdown becomes necessary. Our problem from here on is to keep that winning superiority and enough besides to remove the threat of war.

Productivity is the job of getting more with what you have. It means better methods, better machines, substitute materials to take the place of those in short supply, reduction of waste and the application of scientific discovery. And while we are finding out how to make better use of what we have, we are making more of it available for the expenditure of an hour of labor.

Productivity is the foundation on which our national defense rests. It is the basis for our American standard of living. It is the only way in which inflation can be kept in check. The engineer is the man to whom we must look for the techniques, the methods, the know-how.

Engineering Needs Broad Thinkers

That is a big job and it is getting bigger all the time. For that reason men are needed who have a breadth of concept and who can think and think big.

Engineering basically is the application of scientific knowledge. Engineering, however, because it lives in the realm of practicality, does not and cannot have the exactness of science.

Engineering for industry of necessity is a compromise. For the most part our problems involve the weighing of a great many factors and conditions. If it were possible to have a single answer then our engineering problem would be simple because then we could design a computer to do all of our engineering work.

Seldom is there one and only one correct answer. As a rule there is a choice of directions to take and it is even possible at times to have solutions that appear to be almost 180 degrees apart. Because this is the case industry wants men who are broad enough in their thinking to see all the possibilities and sound enough in their judgment to give them their proper weight.

For years engineering school faculties have asked industry what it wanted in the educational program. It has been a sincere search and just as sincerely industry has said to train the boys in the fundamentals. Industry still says this, but I am not at all sure that industry has made it clear, or that our engineering schools have always understood what was meant by fundamentals.

Balanced Curriculums Offered

Too often, I am afraid, this has been taken to mean the mathematics and scientific principles of the particular brand of engineering. Such a narrow interpretation gives rigidity to instruction and restricts the student's thinking at a time when he should be expanding his outlook.

Of course, not all schools hold to the narrow interpretation. The more progressive ones have shown an understanding of the needs of men who will go into industry by offering them a balanced curriculum.

I have heard it said, as I am sure you you have, that there is a noticeable tendency among engineers to become introverts. As an example of this tendency, it is pointed out that engineers fraternize more with other engineers and are more shy with other members of the public. How much of this there is I do not know, but there is enough at least to have made it noticeable.

It would be difficult for me to believe that engineering attracted introverts, but I can understand how men who have not had a broad education, and who, by the very nature of their work, are not forced to have many public contacts, can have somewhat restricted social interests. This to me does not signify any inferiority complex as attaching to the profession but rather reliance for social contacts in a narrow area of compatibility.

Men in other professions such as law, medicine, and the ministry, are, by the very nature of their work, thrown constantly into close personal contact with lay people. Their interests have to be those of the people they work with and for. Engineers, on the other hand, are not so often required to sit down with lay people. That they fraternize more with birds of the same feather is understandable, particularly if their education was restricted to a narrow interpretation of fundamentals.

Stimulate Outside Interests

Industry would be much better served by engineers who have the interest to grow outside the boundaries of their profession. Stimulation of this interest, of course, can and does take place frequently after the men have left school and are on the job. It seems to me, though, that more could be gained by orientation in the early years of schooling. The idea is not new but, I am afraid, the practice is too often perfunctory, especially if the sessions are conducted by someone who knows the words but not the music.

Those of us who have had a diversified experience in industry can see a great many opportunities for engineers. How much better it would be if engineering students saw these in their early undergraduate years so they could make better choices in their electives. Can it be that the declining enrollment in engineering schools is a reflection of a growing public feeling that engineering offers less opportunity than other occupations?

Engineering Offers Many Opportunities

The nice thing about engineering is that it *does* have so many opportunities, more opportunities as a rule than there are experienced men to fill them. My company, for instance, is a large employer of engineers but we are constantly hard pressed to find enough management men for our expanding production facilities. This year we expect to start construction or put into operation new factories in nearly a dozen different places. Not only does our industrial relations department keep close watch on men of promise within the company but it refuses to permit men who are ready for larger responsibility to be held back by supervisors who are reluctant to give them up. Nevertheless, it is not easy to find the kind of men we want for the more important jobs.

The men we want most are those who have a deep respect for hard, honest work and an abiding faith in the justice of the rewards that come from such work. We need young men who have a mature outlook with respect to occupational integrity and a realization that they are no longer children who have a right to be cared for, but are now men who must be worthy of their hire. We want men capable of growing and becoming leaders. We want men who can adjust themselves to changing conditions without losing vision. We want men who are flexible

enough to accept new ideas, yet so rigid in their principles that they will not shirk responsibility or lose any of their incentive to reach their goals.

Important Fundamentals

Here are some fundamentals, it seems to me, that are just as important as the basic theory of electricity or an understanding of differential equations.

As you can see, we are looking for engineers who can grow and we expect to get them. By no means are we as discouraged as a friend of mine who, after discussing industry's needs all one afternoon, was asked by a college president what the colleges could do differently. His reply was, "well at least you can teach them to read and write."

Maybe that was a little harsh, but I can say "Amen" to the writing part and add speaking, as well. It does not do a man much good to have ideas if he cannot make somebody else understand what is in his mind. Until thought transference, or mental telepathy is perfected, I am afraid we must rely on the normal means of communication.

Engineering manpower for industry, as I have tried to show, is not a subject that can be discussed entirely quantitively. There is a quality angle as well.

Quality Deficiency

A quantity deficiency is no more serious than a shortage of some critical materials. Ways will be found to use what we have more effectively. Supply will be increased wherever possible and substitutes will be sought. A deficiency in supply of men qualified to grow into important positions is a much more serious matter and one that should concern us not only for the moment, but for the future. Surveys have been made of the number of men graduating from engineering schools each year and the number still to graduate. Do we know nearly as well how many engineers are needed?

What is normal? Are our schools geared for that figure or are they geared to carry a peak load? Is it, for financial reasons, a temptation to take in all the students that can be accommodated without thought for the employment opportunities for graduates?

When colleges take in too many for the demand, the pay drops and until fairly recently, engineers as a whole were not well paid. When the supply is more than adequate more men get pushed into blind corners where opportunity ceases to exist. Too many engineers make employers careless of their use.

Fewer Graduates

Right now, and for several years, the number of men graduating from engineering schools will be considerably less than before. In numbers they apparently will not be enough and something else must be done to make up the deficiency. The concern of industry will be whether the classes of the next few years will make up in quality what they will lack in quantity.

With fewer students the engineering schools should be able to give more attention to the individual and perhaps more time to counsel with him, and inspire him.

It is true that with very small classes almost anybody who graduates can get a job. It is equally true, however, that should such conditions last more than a year or two, as it appears they will, the need for especially well-trained men will be greater than ever.

Emergency caused manpower shortages, such as we have today, can be solved by emergency measures, whether it be mechanics or engineers. Shortages which spring from other causes should be studied to find out why they exist and measures taken to remove the causes.

Only let us be sure, before we start building back too far, we know how many are needed. Let us be sure we know what the men are being trained for and that the work cannot be done as well or better by someone who has not had a formal education.

In other words, let us know what we are doing from here on in, and why.

The Point 4 Program: A Challenge to Engineering *

By DR. HENRY G. BENNETT

Administrator, Technical Cooperation Administration, Department of State
President, Oklahoma A. & M. College

I am grateful for the opportunity to meet with the members of this society because you represent a field of endeavor which is of vital importance to progress in our nation and the rest of the free world. I am also grateful for the chance to visit with my friend and colleague, President Hannah, who as most of you know, is a member of President Truman's advisory board on the Point 4 program. Tonight I want to talk with you about the Point 4 program, which I have the honor to serve.

In seven months I have discovered some remarkable things about the Point 4 program. One is that almost everybody seems to like the idea of the program even if he doesn't know much about the details. Another is that practically everybody who gets to know about Point 4—wants to do something to make it a success.

I suspect this society is interested in the Point 4 program and that you are going to want to do something about helping it along. Otherwise you would not have invited me here this evening. At any rate, I am proceeding on that assumption. All you are going to hear from me tonight is talk about Point 4 and the role that engineering and engineering education can play in spreading its effectiveness.

Because of my work in the Point 4 program, I am particularly aware these days of the importance of engineering and engineering education in promoting the economic welfare of people everywhere. I say particularly aware because under ordinary circumstances I may go for days without giving engineering a thought. And that is in spite of the fact that as an old Oklahoma dirt farmer I have had occasion to brush against several fields of engineering—soil engineering, chemical engineering, agricultural engineering, food engineering, as well as the civil and mechanical fields most people think of as engineering. For the fact remains that many of us do not stop to think about engineers or engineering until we see a bridge being built to span a great river or a superhighway being cut through a mountain.

We in the Point 4 program are constantly being reminded of the vital role that engineering plays in modern life because of the sharp contrasts we see between life in America and life in the places where the Point 4 program functions, the so-called underdeveloped areas of the world.

Close to the People

We now have more than 400 technicians working in some 30 countries in Latin America, Africa, the Middle East and Asia on Point 4 projects. These technicians work with government officials who may be either popularly elected or hereditary monarchs and on a grass roots level with plain citizens in cities and on farms. The work of our technicians is mainly in cooperative efforts to teach people to raise food production, to wipe

* Presented at the Annual banquet of the ASEE, East Lansing, Michigan, June 28, 1951.

out disease and to improve and expand their educational systems. But Point 4 workers are engaged, also, in advising governments on how to modernize their administration and services, in advising on programs of general economic development involving the construction of power plants and irrigation systems, and in the establishment and efficient operation of new industries and the modernization of old ones.

These Point 4 technicians are engaged in demonstrating and teaching technical skills rather than in spending money for capital investment. They are not building public works with American taxpayers' money. Rather they are advising foreign governments on the proper way to build public works financed with local capital or loans from outside sources.

But regardless of the particular project a particular technician may be engaged in, he is likely to be dealing at least part of the time with problems involving engineering.

In the United States just about everything we see, touch or taste in our everyday life is the product of some kind of engineering skill. Pasteurized milk is an old example but concentrated milk is new. Rayon is relatively old but orlon and dacron are comparatively recent. Automobiles and airplanes are familiar means of transport but automatic transmissions and jet engines are new. Radio and motion pictures are taken for granted, but color television is only beginning. All these things, however, the old versions and the new, are the products of research on which engineering has been applied to bring them to multitudes of consumers at reasonable prices.

The contrast is astounding when we turn to the underdeveloped areas.

Toward Self-Sufficiency

For example, a few years ago Panama wanted to increase rice production. One of our technicians went down there—this was before technical cooperation became an official arm of U. S. foreign policy on a world-wide scale—and found that because the Panamanian farmer used ancient methods of cultivation he could not possibly take care of more than 2½ acres of rice a year. Our man showed the farmer how to use certain kinds of equipment and he was soon cultivating as much as 50 acres single-handed. Now Panama is self-sufficient in rice production and we have a new market for farm equipment.

Our people looked over the economic problems of Iraq. They found that the Tigris and Euphrates Rivers rage unchecked in flood season and fall to a comparative trickle in the dry season. The result is that 7,000,000 acres of land are useless for agriculture and that an area of equal size is not as productive as it should be. We are sending engineers to Iraq to advise on flood control and irrigation works construction.

I've been struck by some of the things I've seen myself. In Ethiopia I found topsoil 12 feet deep. That country could produce enough food to supply all the people of Europe. That is if its farming and farm processing were modernized and if it had roads and harbors so that its production could be taken to market —all engineering problems in greater or lesser degree.

In general I can say that engineering and engineering education have been lagging in underdeveloped countries. We find wonderful examples of scientific research which are useless because the engineering knowledge is lacking so that they can be widely and economically applied. Here a plant scientist has developed an excellent new strain of wheat: high-yielding, disease resistant, hardy in dry soil. But there is no way for the farmer to take advantage of it. It is as if Fleming discovered penicillin but people kept dying of disease because there was no engineering skill to produce the drug in large quantity and at low cost so that the majority of people could make use of it.

So the fact is that lack of engineering skill and knowledge is one of the reasons why the average income in underdeveloped areas is one-tenth or less of ours, why millions live between malnutrition and actual starvation, why two persons out of every three suffer from malaria or some other preventable disease.

The fact is that engineering is one of the supporting pillars of our own prosperity and that it is one of the absolute essentials for swift and sound economic progress in underdeveloped areas.

Great Need for Engineers

What we need now and are going to need more each year is a corps of engineers trained in all branches of the profession who can put their skills into practice in foreign lands, and more than that, who can teach their skills to the people of foreign lands. We need and will increasingly need people who are both engineers and educators. It is because this need exists that I am particularly happy to be talking to you tonight. I hope you will put this problem of increasing engineering knowledge and education in the underdeveloped areas of the world on your list of important things to be done.

The more we study the problems of underdeveloped areas the more we realize that the gap between their standards of life and ours is mainly a gap in engineering skills. The Point 4 program is designed to bridge that gap by making some of our knowledge and skill available to other people. And I am pleased to be able to tell you about some experiences which prove that this process is effective and that it is relatively low in cost.

For example, *Civil Engineering:* One of the major handicaps of the underdeveloped countries is lack of transportation and communications. Take Africa as an example—a continent more than 5400 miles from north to south and 4500 miles from east to west, with no through routes, either railroads or highways, for transporting people or merchandise. In fact, there are few miles of railroads or reliable highways on the whole continent. The same problem exists in many parts of Latin America and Asia. In some areas, the wheel is still unknown. Yet the building of roads is possibly the greatest single means of opening up new regions to development and quickening the economic life of a people.

Assist in Planning Roads

Under Point 4, we are sending engineers of the Bureau of Public Roads to countries that ask for technical help in solving their transportation problems. Often, their surveying and planning paves the way for private American engineering firms to build roads under contract. We hope that the services of private companies will be increasingly in demand as our Point 4 technicians point up the need of building roads and show how it can be done.

In Bolivia there is a great potential food producing region larger than Texas lying east of the high Andes. American agricultural technicians are working with the Bolivians to solve the technical problems of growing food, raising cattle and cutting timber under humid, tropical conditions. But probably the real key to the situation is transportation to get the food from the fertile lowlands to the food-deficient high plains of the Andes, where the majority of the Bolivian population is concentrated. A highway is now being built by American contractors to connect with a railroad leading to the capital. The Bolivian government is paying for this, partly with its own funds and partly with a loan from the Export-Import Bank.

Aeronautical Engineering: Many of these countries, although still needing railroads and highways for bulk transportation, have leaped into the air age while still depending mainly on the ox cart. In some countries, the airplane is the only means of cross-country travel. They need new, improved airports and

all the services that go with air transportation. Aeronautical engineering itself, with its constant improvement of plane design and performance, will continue to contribute to the economic development of these countries.

Nautical Engineering: Some underdeveloped areas possess extensive water highways—great river systems like the Amazon, which could accommodate far more shipping than is now using these waters. This situation, it seems to me, is a challenge to nautical engineering. There must be ways, yet undiscovered for designing craft for more economical and efficient operation in areas where waterways are the main arteries of travel and trade.

Harbors and Docks

Harbor development and dock facilities are also among the urgent needs of many countries that want to expand their foreign trade. When I was in Ecuador recently, the Government there requested the assistance of American engineers in developing plans for opening up the port of Guayaquil to ocean shiping, so that large ships could take on and discharge cargo there, instead of having to stop some distance down the river and use lighters, as at present. We promptly sent an experienced American engineer to look into the possibilities of that project.

Our records are filled with examples of amazing results achieved by American sanitary engineers working abroad. The water supply and sewage systems they have planned and supervised in communities in Brazil, Mexico, Chile and other countries have brought a dramatic drop in typhoid and dysentery. The draining of swamps, coupled with the application of insecticides and other measures, has brought an equally dramatic reduction in the incidence of malaria, the scourge of the tropics.

Geological and Mining Engineering: We all know that one of man's great sources of real wealth is the minerals brought out of the ground. Yet probably half the world has never had a thorough geological survey with modern methods. Most people consider Africa a poor continent, without stopping to think of the gold, diamonds and other treasures taken from African mines.

More Precious than Gold

Yet today precious metals and gems are not the most valuable materials we get from the earth. In the aggregate, the oil and coal extracted every year are worth far more than the gold and diamonds. One of the greatest needs of many countries is to find and use sources of economical fuel. The baser metals, including iron ore, are essential to economic development. Nor are metals and fuels all we need. I was told recently in Bolivia, where fortunes in gold, silver, tin and other minerals have been mined, that the government would like to have a geological survey in the hope of finding, among other things, phosphate and lime that would help the country produce enough food.

Under Point 4, we have geologists in twelve countries of Latin America, Africa and Asia helping to make inventories of mineral wealth and ground water supplies. In some instances, our mining engineers are helping work out more economical and efficient extraction methods. American geologists working with Brazilian geologists have scientifically confirmed the existence of rich magnanese deposits, with the result that American steel companies are going into partnership with Brazilian capital to develop these deposits. I am convinced that unknown treasures remain to be discovered and mined in Africa, Latin America and other parts of the world, and that our geological and mining engineers can help the people of those countries find and develop vast new sources of wealth.

Electrical Engineering: Many countries without coal or oil have another great source of energy—water power. Civilization really begins with the harnessing of heat energy for the work of man. Human slavery has been elimi-

nated largely because man has found other and far more efficient sources of energy—mechanical power that has enabled our own people in this country to multiply their own physical strength many times over. Our coal, oil and waterpower have made possible our amazing industrial development, and the same is true of Britain, Germany and other industrialized nations. And rural electrification has done more to increase our agricultural production than many of us realize.

The same thing can be done in the less developed countries. We know that Africa, for example, has some of the greatest unused water-power in the world —in the Nile, the Zambesi and other rivers. The same is true of many countries in Latin America. In the development and utilization of hydroelectric power, America can furnish much of the engineering knowledge to provide other countries with the mechanical energy that is essential for their progress.

Agricultural Engineering: Here is one of the most varied and most promising fields of all. Most of the underdeveloped countries are in the tropics, where the rain falls in torrents in some seasons and there is drought in other seasons. The hot sun rapidly leaches the nutrients out of the soil. When we clear and cultivate the land under these conditions, we have to protect it with dams, catchments, terracing, cover crops and other methods that are well-known. These measures are necessary to keep the top soil from washing away and the plant food from being lost.

Water is Pressing Need

The major limiting factor on food production and economic development in general in the semi-arid areas of North Africa and the Near East is lack of water. The people of that area need to store up the water in the rainy season and use it for irrigation in the dry season. The Romans largely solved that problem 2000 years ago. All through North Africa and the Middle East, we find the remnants of the dams, reservoirs and canals which in Roman times enabled that area to support much larger populations that can exist there today. We recently made a contract with the American engineering firm of Knappen, Tibbetts and Abbott to go into Jordan and show the people how to restore and expand these old Roman works so that they will have enough water. The same thing can be done in other countries of that area. It is not a costly process, because most of the work can be done by the people themselves, with local materials.

I want to explain that Point 4 is not in the business of building or financing large-scale projects in other countries. We help with the planning and technical direction, but the cost of construction must be borne by the other country with its own money, with help from private investors or with loans from international lending agencies. Many of these projects can be financed on a self-liquidating basis. At any rate, the cost need not fall on the American taxpayer.

For the last eight or nine years, American agricultural technicians, including engineers, have been cooperating with Peru in a joint service under the able leadership of Jack Neale of the Institute of Inter-American Affairs. I want to tell you about just one of the things that have been done.

Along the coast of Peru, as you know, is a strip of desert, caused by unusual climatic conditions. There is no vegetation except where the few rivers run from the mountains into the sea, and sometimes even these dry up. One such river is the Piura, in northern Peru. In normal years the farmers in the Piura valley grow the only crop of long-staple Pima cotton in Peru. It sells at a premium and ordinarily brings in about $8,000,000 a year. But for the last three years the river has practically dried up. The loss in the cotton crop is conservatively estimated at $15,000,000.

Find Way to Join Rivers

Nearby is another river that does not dry up. Agricultural engineers of the joint service made studies that showed that the waters of the constantly-flowing river could be diverted to the Piura. This would not only assure a cotton crop every year, but also add another 50,000 acres to the 75,000 now under cultivation. As a result of those studies, the Peruvian government is now considering contracting with an American engineering firm to construct a short tunnel to save the cotton farmers.

Even more important than bringing new land under cultivation, however, is the multitude of little things which, repeated by large numbers of farmers, are increasing production on the land already in use. These are simple things. In some cases, it means designing a suitable steel plow to replace or supplement an inefficient wooden plow. It means introducing a little better cultivating or threshing implement. We need engineers with the vision and the ability to work out and adapt these simple improvements that the people themselves can apply with their own resources.

Food Engineering: In most underdeveloped areas, harvest time is feast time; the rest of the year is hungry time. The people have no way of conserving food in order to tide them over to the next harvest. In the United States, we probably lose ten per cent of our agricultural products through spoilage, insect infestation and waste. In some countries, the loss must be 25 per cent or more. In Africa I have seen millions of cattle, and not a packing plant.

In parts of Costa Rica the farmers can produce two crops of corn a year, but the rainfall is so heavy that the grain sprouts on the stalk, and much of what is harvested is ruined by mold and insects. Point 4 technicians there showed the farmers how to build a simple corn drier, which resulted almost immediately in better prices for corn and an increase in production. An expert in milling was brought from Kansas for a few months, and as a result of his technical advice, an agency of the Costa Rican government has built modern grain elevators, a quick-freeze plant and cold storage facilities with its own funds. In Peru, a fisheries expert from our Department of Interior is helping the fishermen increase their catch. Another American agricultural engineer has helped construct a cold storage plant in Lima that will assure the people a constant supply of fish at reasonable cost.

Chemical Engineering: Closely related to food engineering is chemical engineering, with the contributions it has made to the food industry. Chemical engineers can make many valuable contributions to the progress of other peoples. The insecticides, weed-killers and the like already in use in our own country, if applied and adapted for use in other areas, can increase the production and utilization of food. I understand that there is a shortage of wood pulp and other material for cellulose products in the industrial nations. Yet in the tropical regions are wide stretches of forests waiting to supply the demand.

Purifying Sea Water

One of the most intriguing possibilities of all is that chemists will devise an economical efficient way to purify sea water by removing the salts, and make that limitless source of water available for irrigating desert places like the Sahara and the west coast of South America. Two things are needed to make this dream a reality: first, practical processes for purifying the water in large volume and, second, cheap power, possibly from atomic energy or solar energy. We must look to engineering for both answers.

Industrial Engineering: An increase in agricultural production naturally leads to industrial development. But it is a step by step process—little industries that eventually lead to big industries. As the people learn to produce more food and as surplus food production frees

labor from the field, raw materials for small industries become available, along with the labor to process them.

This is a gap that needs to be closed in most of the rural countries. I referred to the millions of cattle I saw in Africa, without packing plants to process and preserve the meat, the hides and by-products. The people there, and in comparable areas, don't need large, expensive factories. They need a little local packing plant, a little local shoe factory, a little local textile mill. They don't need vast amounts of capital from outside. They need to *know how* to use their own capital, their own raw materials, their own resources, to produce for their own vast internal markets. An American technician in Bolivia reports that Bolivians have asked him how they might profitably and safely invest a million dollars in local enterprises. There is a job—an almost limitless job—for American industrial engineering in the other regions of the earth.

Architectural Engineering: A house, or a hospital, or a factory, is not just four walls and a roof. It is a product of engineering that plans and constructs each buiding to serve a particular purpose. The underdeveloped countries need the techniques of American designers and structural engineers. They need the advice of our housing experts. And it isn't just a question of exporting our own designs and techniques. We have got to use imagination and ingenuity in the use of local materials to meet local economic, climatic and social conditions that vary widely from country to country. In some countries the best material for housing is bamboo, in others rammed earth may be the best answer, in still others, tile from local clays.

I think these examples cover enough ground to show that it is practical to try to fill the breach in engineering knowledge in foreign countries and that, as I said, the cost of applying technical knowledge to foreign problems is very small considering the progress that results.

Strategic Need for Technicians

The point I would like to emphasize again to this audience is that we must do more than merely send our technicians into foreign countries to supervise engineering projects. In the first place we do not have enough technical men to do the economic development job that needs to be done as fast as it needs to be done. In the second place we are interested in having foreign peoples learn to do their own engineering. It will not be enough merely to provide the technical advice to set up one irrigation system; we want people to be able to build their own. So we must do all we can to expand the corps of trained engineers in underdeveloped areas.

Further we must be imaginative about spreading engineering knowledge and engineering education. We need an imaginative, pioneering approach. The stress that a steel girder of given size will stand is standard but American engineering problems often are not identical with engineering problems in Africa, Asia and Latin America. So we must cooperate with foreign peoples in developing African, Asian and Latin American engineering, using our basic knowledge as the foundation and our imaginations to solve particular kinds of problems the quickest, cheapest and yet most effective way.

I think this society is especially equipped by experience and purpose to help in this process of spreading engineering knowledge and encouraging engineering training. I hope you will work with us to that end. I have no point-by-point program to propose to you. I am merely outlining a problem whose nature will undoubtedly suggest solutions to you if you can spare the time to think seriously about it.

I hope you will be as enthusiastic about solving this problem as I am because I thing the challenge of Point 4 to American engineering is one of the most exciting things that has ever happended to a romantic, though largely unsung, profession.

Judging the Effectiveness of Teaching Aids*

By CARL W. MUHLENBRUCH

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After the symposium on teaching aids at the annual meeting of ASEE at Rensselaer in 1949, the author overheard an individual remark, "I still think the best teaching aid is a piece of chalk." This individual was engaged in conversation and shown some of the teaching devices on display, with special reference to the unusual opportunities which they presented to the instructor and the student. The skeptic was apparently convinced. It was with a great deal of pleasure that he informed me at Seattle last year that he had carefully considered the matter and had decided to revise his teaching procedure considerably. This chap is now using colored chalk!

Here is one extreme in a field in which the middle ground is vast indeed. By contrast, there is one school which is considering having several question-asking machines located in the corridors. Each of these machines will have approximately 600 questions contained in its "brain." These will cover a great range of the core subjects in engineering. The student will place an identification card in the machine and attempt to answer the questions as they are presented to him by the mechanical gadget. At the end of a specified number of questions the machine will shut itself off, grade the student, record the date, the number of the machine, the sequence of question numbers, and the percentile score.

Some place in the middle ground between these two extremes there is a teaching aid which can properly be used by an engineering teacher for some particular subject. It is the purpose of this paper to examine this middle ground by looking at the following points:

1. Types of teaching aids
2. Some advantages and disadvantages of teaching aids
3. What can be used as a yard stick for evaluating a teaching aid for a particular instructor and course
4. The cost of producing teaching aids in the engineering college
5. The difficulties of using teaching aids, particularly the motion picture and slide type, in rooms not adapted for the purpose
6. The work of the Teaching Aids Committee of ASEE in reviewing and cataloging teaching aids

First it will be necessary to define the basic function of the teacher. In this paper it will be assumed that the principal job of the teacher is to provide, by means of his presentation, a high order of interest quotient which will get the student to learn. The term "teacher" is thus somewhat of a misnomer since the student must actually teach himself if he is to learn in the full sense of the word. The best way an engineering instructor can motivate his students to learn is by presenting the material in a way that will arouse the students' curiosity so that they will learn and thus gain understanding.

* Presented before the Division of Engineering Drawing at the Annual Meeting of the ASEE, East Lansing, Michigan, June 25, 1951.

Types of Teaching Aids

The entire field of teaching aids was summarized at the 1948 annual meeting of ASEE by Professor W. J. King in a paper titled "Industry-College Cooperation in Developing Teaching Aids."† In this paper Professor King listed fourteen different teaching aids under the general classifications of full-scale models, small-scale models, cut-away samples, small parts and mechanisms, laboratory apparatus, industrial displays, pictorial displays, catalogs, lantern slides, and talks by outstanding leaders of industry. Breakdowns of each of Professor King's classifications can be made and others can be added. This paper refers to all types of teaching aids except lectures by practicing engineers.

Some Advantages and Disadvantages of Teaching Aids

Proponents of teaching aids have often been convicted of being gadgeteers who let their hobbies run away with them. In some cases this is undoubtedly true, but certainly not in all cases. The accusation, however, must be considered. It brings up a very important consideration that every teacher must keep in mind when he judges the worth of any teaching aid for his own use: the device should not be a terminal point in itself. It must set the mental stage for the student by motivating him through interest or curiosity to go on to a full understanding by the working of problems. The device may even be of such a type that the student can actually use it to pose and solve problems. In the case of a motion picture of a turbine, for example, the student could be shown how the turbine is assembled, how it operates, and how some variables influence its operation. The use of the film should not be limited to this point insofar as teaching is concerned. The student should be given problems which bring out some of the points presented in the film and should be made to solve these problems within a few minutes after the film is shown. An excellent idea in films for engineering teaching would be to have the film itself wind up with a question mark by posing a problem which the student would then solve. A most unfortunate circumstance is the use of a device which can be carried to the classroom, demonstrated by the instructor to the amusement and possible edification of the student and then put back in its case and, with a smug smile, carried out of the classroom. Such a device could of course do a job of motivation, but the real true follow-through in the learning process will come by having the student solve problems for complete understanding. Therefore, a teaching aid that can be used by the student to pose and solve a problem is, in the author's opinion, the ideal one.

On the credit side of the ledger, teaching aids are very helpful in undoing incorrect ideas that have become firmly rooted in the mind of the student. They can be used to build carefully on a few fundamentals by a process which can always be repeated (as in the screening of a film, for example) and can be improved from time to time. Many teachers are aware that the illustrations in textbooks are often actually misleading to students. The average engineering student will look at such an illustration and see the complete finished product but is unable to strip it down to its fundamentals or to read the text and follow the manner in which the chart was developed. Of course the teacher in working at the board presents the material in the correct way since he starts with a blank board and through oral and visual presentation develops the entire diagram. This is the way in which it can be done in the film, very often in a time saving way. It is up to the teacher to decide just when the saving of time should stop and therefore just which diagrams should be presented slowly and apparently laboriously, but still effectually, at the board and which should be presented in

† See October, 1948, issue of the JOURNAL OF ENGINEERING EDUCATION, Vol. 39–2, pp. 90–94.

animated form in movies or perhaps by slides. It is reasonable to assume that a few diagrams presented slowly and carefully in motion picture form would make for much faster and more complete understanding of subsequent diagrams presented in their entirety.

It goes without saying that a gadgeteer will let his gadgets run away with him. The good engineering teacher will select teaching aids so that they do things for him that he cannot do for himself or do them in a much better way, thus justifying their use. Teaching aids are not like frosting on a cake to make the course sweet to the student. They may be interesting in themselves but they will not be effective teaching aids unless they satisfy the basic requirements of encouraging and aiding the student to carry out the learning process himself.

A Yardstick for Evaluating a Teaching Aid

What can the engineering teacher do to decide if a certain teaching aid can be used by him for a particular presentation in a certain subject? Questions that come to mind are: whether or not the device is adapted to his particular way of teaching, including his philosophical approach to the subject; whether it will do the job which he hopes it will do; and a host of other complications. Actually the answer is very simple. The teacher merely needs to ask himself whether it wil help him do a better job of motivating the student to learn. To be more specific, the teacher needs to know whether it will do a better job of (a) presenting ordinary information, (b) presenting information that cannot be presented in any other way, or (c) in motivating the student in developing a sense of professional consciousness (or interest in the humanistic-social stem courses).

The engineering teacher finds it necessary to present two kinds of information, descriptive and technical. Teaching aids often offer an advantage in presenting descriptive material by enabling the teacher to present the information more rapidly and more thoroughly. It is doubtful if many instructors are describing the steel making process with a word picture today. It is so much easier to use a set of slides or a motion picture or better yet actually to visit a steel mill. The time consumed in the visual presentation is so much less and so much more efficient and thorough that the word picture cannot compare with it. Very often technical information can be explained in a much better fashion by the use of animation, as, for example, to explain the meaning of a certain formula. Animation may be done by means of models which can be carried to the classroom or it may be done with a motion picture of the model in operation. An advantage of the motion picture is the knowledge beforehand that it will always do exactly the thing that the instructor wants it to. The disadvantage is that the instructor is unable to allow the student to pose problems other than those which have been solved by the model or explained by means of the model in the motion picture. It might be impossible in a classroom presentation to explain what would happen in a centrifugal pump if the speed of the pump was increased or if the length of the impellar vanes was increased. However, this can be done schematically using data which can be gathered and shown very quickly in a film. There will be other cases where the film will not do a complete and proper job of presenting the material, and if it sets up too simple and pat a case, may actually be misleading. Again, each instructor must evaluate every teaching aid to be sure that the device will not be a terminal point in itself. It must lead to something. In order to place emphasis upon the learning process, the device must permit operation by the student or must in some way stimulate him to further study. In this respect the teaching aid itself is actually motivation, although it basically does help speed up the rate of understanding.

Some teaching aids will permit the presentation of information and under-

standing that cannot be presented in other ways. The high speed motion picture, referred to as the "time microscope," is well known in the dynamics field. Here the student is able to see certain dynamic effects as they influence the operation of high speed machinery, and he is able to visualize machine design problems in a way that could not be done otherwise. Other examples would be the action inside a furnace, where high temperature would prevent ordinary observation, or perhaps the action in proximity to an explosion or a test to failure. A further possibility is that by means of the teaching aid the student is given a pseudo-experience which could not be obtained by reading text material. This of course is desirable in many subjects.

An important function which the engineering instructor must often perform is to motivate the student to an interest in professional matters or perhaps in the humanistic-social aspects of the engineering profession. This can often be done with motion pictures or slides, as, for example, in showing a long range city planning program where slums are cleared and replaced with more desirable low cost housing. It can be shown quickly how transportation can be improved, and the general welfare of the community benefited, if the engineer plans wisely with an overall humanistic-social and economic consciousness. Such a viewpoint is difficult to present in textbooks.

To repeat once more the second point of this paper, the student will remember longer what he sees if he is able to put it to some quantitative use shortly after seeing it. Avoiding the use of the teaching aid as a terminal point and stressing the actual learning process makes for a higher retentivity.

The Cost of Producing Teaching Aids

Many college teachers wishing to make their own motion pictures have been discouraged by the $25,000 to $50,000 cost of a 20 minute industrially sponsored film. It is doubtful if any school could afford such an amount. Actually, however, it is possible to produce creditable and very effective silent films in color of 20 minute showing for $300 in student labor and supplies. The author has produced such a film with about 22 minutes showing time on the subject of "FATIGUE—The Failure of Materials Due to Repeated Loading" for an actual cost of $276. This did not include a charge for personally owned photographic equipment or for space or other overhead charges. A sound track could be added to the film by a professional narrator and one print provided for approximately $300. This cost can be reduced by recording the narration and musical background on tape and supplying this to the commercial firm making the sound on film print. With equipment and space at hand it is therefore possible to produce a sound film in color for 20 minutes showing at a cost of approximately $500 to $750.

The author introduces animation into a motion picture by means of simple cardboard cutouts that are schematic representations of mechanisms and other devices. The device shown in Fig. 1 is used to show ballast "pounding" under a railroad rail and the resultant bending of the rail. The rail is fastened to long wooden handles at each end. These are pivoted to allow the rail to be bent. Ballast, in the form of one-half inch top size crushed limestone, is placed around the ties. The wheel is painted on the back with rubber cement so that it will "roll" along the rail when pulled over the neutral background by a handle attached to the wheel on its bottom side. The camera sees only the rail, ties, ballast and about 40 per cent of the lower part of the wheel.

The development of a transverse fissure in the head of a rail can also be explained very effectively with animation. A cardboard cross-section of a rail is painted black and is shown to have a small inherent defect represented by a white dot. This defect is made to increase in size through the use of many single frame

FIG. 1. Cardboard cutouts for motion picture animation used to represent bending of a railroad rail under a rolling load. Wood handles fastened to the cardboard at A and B are pivoted to permit application of bending moment. Wheel is 15 in. in diameter.

FIG. 2. High speed stamping mechanism model for motion picture. Forming head, connecting rod and flywheel are moved slightly between single frame exposures.

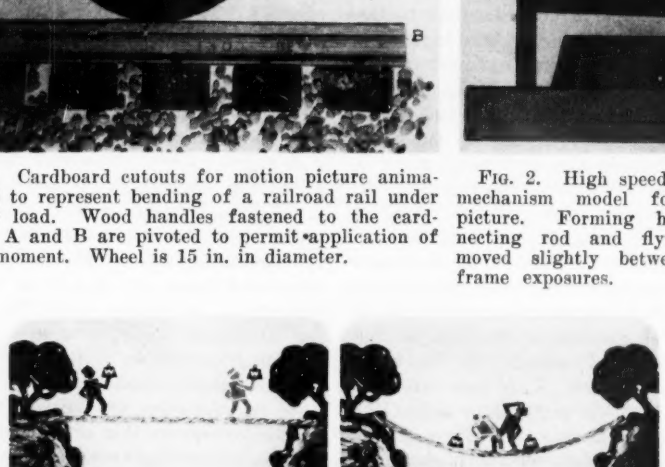

FIG. 3. Individual frames from sound-slide film "Lines of Force." Characters are colored red for tension and blue for compression. Film develops a concept of lines of force in trusses. Reference to "sky hooks" and other ridiculous situations is an attempt to promote interest.

exposures, the dot being enlarged slightly each time. The full size fissure is finally compared with an actual one closely resembling it in size and shape.

A model of a high speed stamping mechanism is shown in Fig. 2. Animation with this device is accomplished with single frame exposures, moving the parts slightly between each exposure.

All of the author's animation models are made of heavy poster board (cardboard). They are painted with show card colors in pastel shades. These paints are completely flat so that there are no annoying highlights to cause photographic difficulties.

The cost of making slides is so small the author does not consider it worth discussing here. A good quality 35 mm. camera with a copying attachment should be available for staff use in every department. Slides in black-and-white or color can be made with such an outfit for a very low unit cost. Some figures used in producing a sound-slide film "Lines of Force" are shown in Fig. 3.

Production of models to illustrate fundamental scientific and engineering principles need not be tedious or expensive. Elaborate devices are seldom as effective teaching aids as simpler versions. The reader is referred to the following articles on this subject which appeared in the JOURNAL of ASEE:

"Demonstration Models—Their Use and Construction," Hartenberg, R.S., April, 1950, Vol. 40, No. 8, pp. 430–434.

"Exhibit of Teaching Aids at the Seattle Meeting," Lutz, S.G., March, 1951, Vol. 41, No. 7, pp. 406–408.

"A New Aid in Teaching Kinematics," LaJoy, M.H., and Larsen, O.M., May, 1951, Vol. 41, No. 9, pp. 542, 543.

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Difficulties in Using Teaching Aids in the Classroom

Most engineering teachers have at one time or another had the usual bout with inverted slide images, improperly darkened and inadequately ventilated rooms, balky projectors, and a host of other evils. Most of these can be overcome by assigning a custodian to the operation and maintenance of visual equipment. A few classrooms can be set aside for projection and designed to prevent lighting and ventilation difficulties. A most unusual classroom for this purpose was designed for New York University by Dr. S. G. Lutz and was described briefly in a spring, 1950, issue of *Life* magazine. One feature of this room is the use of a hand operated supersonic whistle to actuate the slide projector by remote control, thus freeing the instructor to use a pointer or to supplement the slide with the blackboard.

Models should be stored in a convenient place where all instructors can get to them. They should be adequately maintained. In some cases it may be feasible to assign all classes in a subject to one classroom where models, charts, diagrams, and other teaching aids can be conveniently stored for ready use by the instructor.

The Work of the ASEE Committee on Teaching Aids

Several years ago the Division of Educational Methods appointed a sub-committee to study the problem of teaching aids in the engineering colleges and universities. Much of the committee's present activities are concerned with publishing a catalog of teaching aids for use by any one desiring information regarding the devices which are available. This catalog will be sold at nominal cost and will contain information as to where the teaching aid may be obtained, its dimensions and other physical characteristics, any charge involved for its use, and other detail information. The listing will also include a brief description of the device and a review of it prepared by a committee of three qualified educators in the field covered by the teaching aid. The reviewers' comments will indicate, for ex-

ample, the amount of the material that is considered to be advertising (in case the teaching aid was produced by commercial interests), the year level at which the material could be used, the general quality of the narrative explanation used in presenting the material, amount of theory or application, and other pertinent information. The object of the listing of the teaching aid in the catalog would be to enable the potential user to determine the worth of the material and of course to permit him to accept this information in good faith with the assurance that it was prepared by competent individuals. The completion of this catalog will do much to enable engineering teachers to determine the worth of teaching aids in their course presentation.

In order to carry out this reviewing plan the committee is currently raising a fund of $7000 which will be used to pay the major part of the expenses of preparing and publishing the catalog. As this is being written, three-fourths of this amount has been received and it is expected that the remainder can be raised without difficulty.

College Notes

F. W. Tatum, Professor of Electrical Engineering, **Southern Methodist University.** has been named Chairman of the Department of Electrical Engineering at S.M.U. Professor Tatum received his technical education at Columbia University, with degrees of B.S. in E.E. and M.S. in E.E. From 1935 to 1947 he was associated with the American District Telegraph Company and held the position of Engineering Supervisor at the time of his resignation to join the faculty at S. M. U.

. . .

Cornelius Wandmacher, present director of the evening session and associate professor of civil engineering at the Polytechnic Institute of Brooklyn, will become the William Thoms professor of civil engineering and head of that department in the **University of Cincinnati** College of Engineering.

. . .

William A. Edson has been named director of the school of electrical engineering at the **Georgia Institute of Technology**, it was announced by J. W. Mason, dean of engineering, Dr. Edson, who until his recent promotion served as professor of electrical engineering in the school, will replace Dean D. P. Savant who retired as director in July of this year after almost 30 years of loyal service.

Report of the Committee on Atomic Energy Education

Summary of Activities—May 23, 1951

By HENRY ARMSBY

Chairman, ASEE Committee on Atomic Energy

The Committee has held two meetings: on June 2 and 3, 1950, and on May 8, 1951. Regional sub-committees have been formed under the chairmanship of five committee members associated with five major operating centers of the Atomic Energy Commission throughout the U. S.

The Northeastern Regional Sub-committee sponsored an inspection tour for ASEE members at the Brookhaven National Laboratory on April 7, 1951. The ASEE Midatlantic Section meeting at Rutgers on May 12, 1951 was devoted to nuclear engineering education. The Allegheny Section at Carnegie Institute of Technology on April 21, 1951 conducted a panel discussion on the subject on nuclear engineering education.

The Southeastern Regional Sub-committee arranged for five papers on atomic energy to be given at the Fontana Conference on August 28, 29, and 30, 1950 and four atomic energy papers at the Biloxi Meeting of the Southeast Section of ASEE on March 22, 23, and 24, 1951. The Sub-committee is sponsoring a symposium at the Oak Ridge Institute for Nuclear Studies from August 27 to September 6, 1951 under the title of "The Role of the Engineer in Nuclear Development."

The Northwestern Regional Sub-committee sponsored an ASEE Conference at Hanford on February 8 and 9, 1951. Sub-committee members were given a thorough description of Hanford facilities and a tour of the plant. The Southwestern Regional Sub-committee was formed as the result of the ASEE Conference held at Berkeley on December 15–16, 1950, the program of which was devoted to nuclear energy education. Arrangements were made to hold a meeting to organize the Middlewestern Regional Sub-committee at the national convention of ASEE on June 27, 1951.

Certain points of agreement among engineering educators have become evident as the result of these regional meetings. In considering nuclear engineering education all of the groups have stressed: the need for developing competence in basic science, the need for training in human engineering, the need for developing the ability to reach sound economic judgments, the continuing need for fundamental training in recognized major fields of engineering, the desirability of reserving specialized training in nuclear engineering for graduate study, and the importance of continued university-sponsored technical training for engineers working on the national atomic energy program, all within the framework appropriate to the individual engineering school concerned.

At regional conferences AEC representatives have discussed the availability of source materials for nuclear engineering education. On the basis of such discussions the Committee has made two recommendations to the AEC.

a. That the AEC prepare a bibliography of basic materials which would be

of particular interest to engineering educators, for publication as a joint enterprise of the ASEE—AEC—Office of Education. The AEC has agreed to prepare such a bibliography.

b. That AEC sponsor the preparation and publication of a *Sourcebook on Atomic Energy Engineering,* along the lines of Dr. Samuel Glasstone's *Sourcebook on Atomic Energy.*

The Committee feels that there is much more work to be done and is soliciting comments and reports of activities in this field from members of regional subcommittees and all others interested in nuclear engineering education. The Committee chairman will prepare this material in suitable form for circularization to engineering educators. The Committee plans to meet again in May 1952.

College Notes

William G. Van Note, 45, of Raleigh, N. C., will be the ninth president of **Clarkson College of Technology.** The announcement was made today by Ralph S. Damon, president of the Clarkson board of trustees and of Trans-World Airlines, Inc. Van Note is director of the Department of Engineering Research and professor of metallurgy at North Carolina State College, Raleigh. As president of Clarkson he will succeed Jess H. Davis who will become president of Stevens Institute of Technology.

. . .

The appointment of G. R. Fitterer as dean of the Schools of Engineering and Mines at the **University of Pittsburgh** was announced by Dr. R. H. Fitzgerald, chancellor. Fitterer has been professor and head of the department of metallurgical engineering since 1939. He graduated from the Rose Polytechnic Institute in 1924 and during the remainder of that year worked as metallurgist for the American Chain Co. in Terre Haute, Ind. During the next two years he was employed as metallurgist for the Stanley Works in New Britain, Conn.

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Richard F. Shaffer, Associate Professor of Chemical Engineering at **Pratt Institute,** has been appointed Head of the Department of Chemical Engineering, Dean Nelson S. Hibshman announced today.

Lamme Award

The Committee on Lamme Award is always anxious to get nominations for the Award from the membership of the Society. Any member may place a name in nomination; the selection will be made by the Committee by letter ballot.

About March the first each year, the Chairman of the Committee requests nominations from the Committee, and the result is a list of about twenty-five names. By March fifteenth the balloting begins in order that the selection may be made well in advance of the annual convention.

Until February 1, 1952, the Chairman will receive formal nominations from members of the Society. This closing date is fixed in order that names, and accompanying biographies, may be placed in the hands of the Committee members by March first. It is very desirable that nominations be accompanied by a brief statement made according to the outline suggested below.

A number of years ago the Committee set up the following rules for making the Award:

1. Achievements which can be taken as proof of excellence in teaching or as having contributed to the art of technical training will be given major consideration.

2. Only those achievements will be considered which seem to have the possibility of lasting influence or which have sufficiently stood the test of time.

3. Books, articles, contributions to method and research, which have a beneficial effect upon the teaching of engineering, will be given considerable weight in making the decision.

4. Participation in the work of Engineering and Educational Societies is not necessary for eligibility. Such participation, however, will be given due consideration if it has led to definite and recognized results in bettering technical education.

5. Achievements outside of the field of teaching, such as employment in industry, consulting work, inventions, etc., will be considered as of secondary importance in making the Award.

6. Administrators in engineering schools are eligible. Only that work of Administrators, however, will be considered which has led to definite and recognized improvements in method of teaching or in the art of technical training.

7. Emeritus Professors are eligible.

8. Nominations should emphasize the contributions of the candidate to these major objectives. Concise statements of achievements are much more valuable to the Committee than a series of recommendations from former students and present acquaintances. Listings in "Who's Who in Engineering," and such publications, give some information regarding achievements but material of this type will not give the Committee the needed information to make a valid judgment.

In preparing a biography of a nominee the following outline should be helpful:

1. Preparation for teaching work—school, year graduated, degree, postgraduate work, honorary degrees.
2. Accomplishments as a teacher.
3. Advancement of the art of technical training—books, articles, contributions to method, research, etc.
4. Administrative work in engineering schools.
5. Membership and participation in Engineering and Educational Societies.
6. Engineering practice—employment in industry, consulting work, inventions, etc.
7. Other achievements.

Nominations should be sent to the Chairman of the Committee, Nathan W. Dougherty, University of Tennessee, Knoxville 16, Tennessee by February 1, 1952.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The award consists of $1000, together with an engraved certificate. The recipient is selected by a ten-man committee, nine of whom are appointed by the President of the Society. There is also a representative from the Foundation. The Award for 1952 will be presented at the banquet of the annual convention at Dartmouth College, Hanover, N. H., June 23–27, 1952.

The recipient of the Award must have made a significant contribution to the teaching of engineering students and shall have distinguished himself in several of the following ways:

1. Record as a teacher. (Evidence of superior teaching and guidance of students as demonstrated by records of former students, indications of unusual subject matter competence, etc.)
2. Improvements of the tools of teaching. (Textbooks and student notes, descriptions of special courses or curricula, diagrams and models, new laboratory and teaching equipment, etc.)
3. Other activities contributing to the improvement of teaching. (Material relating to the development of teachers in the nominee's department or teachers in general, the development of testing and guidance program for students, the promotion of cooperation with other types of educational units or with industry, coordination of fields of subject matter, etc.)
4. Evidence of high intellectual capacity. (Brilliance of mind as manifested by contributions to literature, degrees and honors received, etc.)

The Award has been established to encourage younger men who have shown by their past record evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before February 1, 1952, to the Chairman of the Committee on Award, Dean R. E. Vivian, University of Southern California, Los Angeles 7, California. Nominations must be made on forms available from either the chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

A Theory of Work Habits of Industriousness*

By WILLIAM C. KRATHWOHL

Director of Tests
Institute for Psychological Services, Illinois Institute of Technology

The work habits which are to be discussed are confined to those of industriousness and indolence.** The theory concerning these work habits is that by means of aptitude and achievement tests in some area a number can be assigned to an individual, called his index of industriousness, which will measure his industriousness in that area.

It should be noted that habits of industriousness are relative instead of absolute and hence with any definition of these traits there must be associated a group with which the individual is compared. Thus a person who would be considered an industrious individual in some activity in the tropics might be considered indolent if he were compared with people in the temperate zones.

In order to test this theory of work habits, it was tried out with a group of 1255 engineering freshmen at the Illinois Institute of Technology in the field of mathematics. To find out what was expected of them, they all took the Iowa Mathematics Aptitude Test, Form M when they entered the Institute. To find out what they had accomplished they all took, during the same week, a locally prepared achievement test called the Mathematics Preparation Test, on the algebra which they had studied in high school. It was assumed that the difference between the scores which they received on these two tests measured their industriousness for mathematics.

In order to make the scores comparable, a linear transformation was used on each set of scores so as to make each mean equal to 20 and each standard deviation equal to 4. Such scores have come to be known as derived scores. They can easily be transformed into standard scores having a mean of 50 and a standard deviation of 10 by multiplying the derived scores by $2\frac{1}{2}$.

Definitions

It was expected that students who made, for example, a score of 22 on the Mathematics Aptitude Test would make approximately a score of 22 on the mathematics achievement test, but in general students did not make the same score on both tests. The difference of a student's derived score on the mathematics achievement test minus his derived score on the mathematics aptitude test was defined to be his index of industriousness for mathematics.

Other definitions which we need are those for industrious, normal and indolent individuals. An industrious person is defined to be one who accomplishes more than is expected of him because of the extra effort expended. whereas an indolent person is defined to be one who accomplishes less. This leaves a third category, that of the normal individual,

* Presented before a joint conference of the Divisions of Mathematics and Educational Methods at the Annual Meeting of the American Society for Engineering Education at East Lansing, Michigan, June 1951.

** For conciseness and also to avoid awkward construction, the word indolence as employed in this investigation is used not in a derogatory sense, but rather as a substitute for under-achievement. In the same way, the word industriousness is used as a substitute for over-achievement.

who does about what is expected of him.

The next question was how to define industrious, normal, and indolent students in terms of these indexes. The rule which was used was the one commonly employed in some fields of statistics, that the middle half of a group should be considered average or normal whereas the highest and lowest quarters should be considered above average and below average, respectively. Such a separation meant that students in the upper quarter of the indexes of industriousness for some subject were considered industrious in that subject with their indexes of industriousness ranging from plus 3 and up. The middle half, which had indexes from -2 to plus 2, were considered the normal group. The lowest quarter having indexes of -3 and less were defined to be indolent in mathematics.

The question now becomes, do indexes of industriousness really measure work habits? If they do, they should satisfy the properties usually associated with work habits.

Postulates of Industriousness

One of these properties is that for the same degree of brightness in mathematics, a group of industrious students in mathematics should receive on the average higher grades in some mathematical subject such as college algebra than the normal group, and the normal group should receive higher grades on the average than the indolent group. This property was found to be generally true is an investigation by Krathwohl (3) who found that the average grades in college algebra for each level of brightness for the industrious groups were always higher than were those for the normal groups. Furthermore, these differences were significant at the 1% level or better for all degrees of brightness with the exception of the group which had the highest average mathematics aptitude score and the two groups who had the lowest mathematics aptitude scores. These three groups were handicapped by the grading system because on an ABCDE grading system, a bright student cannot make a grade higher than A no matter how industrious he is and a student with low ability in mathematics cannot make a grade less than E. In spite of such a handicap, the difference for the brightest industrious group and the brightest normal group was significant at the 9% level and the differences for the two groups with the lowest ability were significant at better than the 5% level.

When the normal and indolent groups were compared, the normal groups still received, on the average, higher grades than the indolent group but the differences were not significant at as high a level. Evidently some members of the indolent group reformed, but not very many. The consistent differences between industrious, normal, and indolent groups when compared at the same level of mathematical aptitude indicated that these indexes of industriousness undoubtedly were a function of work habits.

Persistence

A second property of work habits is their persistency. It has often been said by instructors that students who are industrious at the beginning of their college course usually remain industrious, whereas indolent students rarely reform. This persistence of work habits was verified with the experimental group as shown above, because the indexes of industriousness were computed at the beginning of the freshmen year, whereas the college algebra grades were received from five months to ten months later.

Effect on Achievement

A third property which is expected of work habits is that, for a given degree of brightness, the harder a student works, the greater should be his achievement. Indexes of industriousness for mathematics have this property as was found in another investigation (4). To show that increased industriousness was accompanied by higher grades, correlation coefficients were computed between

TABLE 1

CORRELATION COEFFICIENTS BETWEEN GRADES IN COLLEGE ALGEBRA AND INDEXES OF INDUSTRIOUSNESS FOR MATHEMATICS

N	Mathematics Aptitude	r	Confidence Level	N	Mathematics Aptitude	r	Confidence Level
84	27	0.49	1%	125	21	0.42	1%
76	26	0.45	1%	128	20	0.35	1%
121	25	0.51	1%	85	19	0.30	1%
157	24	0.48	1%	65	18	0.27	3%
186	23	0.49	1%	65	17	0.33	1%
163	22	0.42	1%				

college algebra grades and indexes of industriousness for mathematics for each level of brightness in mathematics. These correlations are shown in Table 1.

In this table the column headed N gives the number of students in the group. The column headed Mathematics Aptitude gives the derived score on the Mathematics Aptitude Test, which measures the brightness of the group in mathematics. The column headed r gives the correlation coefficient between grades in college algebra and indexes of industriousness for mathematics. The column headed Confidence Level gives the level of confidence of the correlation coefficient. Thus a confidence level of 1% means that the correlation coefficient being considered could have happened by change less than once in a hundred times.

It is seen from Table 1, that all of these coefficients are positive which means that the higher the index of industriousness for a given level of mathematical brightness the higher, in general, is the grade received in college algebra. Furthermore, with one exception, these results are significant at better than the 1% level, which means that these coefficients could have occurred by chance less than once in a hundred times. The one exception for a derived score of 18 could have occurred by chance 3 out of a hundred times. Evidently indexes of industriousness for mathematics, as here defined, do satisfy the property that for a given degree of brightness the achievement of a student in college algebra increases with his industriousness. If it did not, all of these correlation coefficients would have been zero or negative.

It is seen from Table 1 that the correlation coefficients for the less bright students are lower than those for the brighter students, which is a fact that has frequently been found in these investigations. It seems that students with low ability are a much more unpredictable group than bright students, and they seem to be much more variable on the whole in their work habits than are bright students. Some are highly motivated to do as good work as they can. Others just do not care as long as they get through. Furthermore, these low ability students are handicapped in that there apparently is a ceiling for low ability students beyond which they are unable to rise no matter how hard they work.

English Compared with Mathematics

For a further test of the validity of indexes of industriousness, as here defined, to measure work habits, another subject, English, was chosen because it is quite different from mathematics. The experimental group consisted of 308 sophomores at the Illinois Institute of Technology who took a vocabulary test as an English aptitude test and the Cooperative Mechanics of Expression Test as an English achievement test when they entered the Institute as freshmen. From these two tests their index of industriousness for English was computed. At the

end of their sophomore year these same students took the sophomore English Expression Test, which is published by the Cooperative Test Service. The results obtained by Krathwohl (5) with the subject of English paralleled closely the results with mathematics. The groups who were rated as industrious at the beginning of their freshmen year received higher average grades in English Expression one year and eight months later than did the normal groups, and this was uniformly true whether they were above average, average or below average on their vocabulary scores. On the other hand, the groups who were rated as indolent at the beginning of their freshmen year still were doing poorer work than the normal groups one year and eight months later.

There was, however, this variation: that whereas the difference for English achievement between the normal and the indolent groups for the students who were above average in vocabulary was significant at the one per cent level of significance, the difference between the normal and indolent groups for the students who were average in English vocabulary was significant at only the five per cent level. Evidently some reformation had taken place, but not much. Furthermore, no comparison could be made in English achievement between the normal and indolent groups for students who were below average in English vocabulary because there was only one student left in the below average indolent group and he was dropped in June.

Ability to Stay in College

This surprising result, that only one student was found in the below average indolent group in English at the end of the sophomore year, was very interesting because it is at variance with the opinions of some engineering instructors who claim that is does not matter what a student does in English as long as he is doing satisfactory work in mathematics, physics, chemistry and engineering subjects.

Similar to the results obtained in English for the ability to survive, were the findings obtained for mathematics. At the end of the freshmen year there were no low ability indolent students in mathematics left in the class, although the theoretical number remaining in this category out of 1255 students should have been 78. In other words, about two years in English or one year in mathematics is the limit of time that low ability indolent students can remain in an engineering school.

The property that the harder a student works in English the higher will be his grade, also turned out to be true. For each level of brightness in English, as measured by vocabulary, the correlation coefficients were positive. Every correlation coefficient was significant with the exception of the group with the lowest scores on the vocabulary test. Both this group, who were the least bright in English, as well as the groups previously mentioned, who were least bright in mathematics, turned out to be somewhat unpredictable. One possible reason for the uncertainty connected with them is that some of the low ability normal students have changed their work habits. Note that there were practically no low ability indolent students in English. A more plausible reason is that similar to the results in mathematics, the low ability group in English are handicapped by a ceiling which sets a limit to their success no matter how industrious they may be.

Average Indexes

An interesting result was found with both the mathematics and English groups when the averages of indexes of industriousness were computed for each level of brightness. It was found that the average index for the brightest students was always negative and the average index for the students with lowest ability was always positive. At first glance it would seem that bright students, as a whole, tend to be indolent. Such a conclusion, however, is not warranted. The reason for this divergence in the averages of indexes of industriousness be-

tween low ability and high ability students is that indexes of industriousness are relative and therefore students of low ability apparently have to work so hard in order to survive that the bright students are made to appear indolent by comparison.

Because the investigations for two such different subjects as mathematics and English gave evidence to justify the hypothesis that indexes of industriousness were measuring work habits, a study was made for English (6) of the relative contributions of vocabulary and an index of industriousness for English to achievement in English. It was found that if the group were taken as a whole, the indexes of industriousness contributed very little to achievement in English. If, however, the original group was divided into subgroups, quite a different picture appeared, and the effect of indexes of industriousness varied greatly for the different subgroups. For instance, when the original group was divided into three subgroups on the basis of being above average, average, or below average in vocabulary, then the index of industriousness or, in other words, work habits, contributed more to achievement than vocabulary, and better predictions for achievement could be made from the indexes of industriousness for English than from the vocabulary scores. If, however, the original group was divided into three subgroups of industrious, normal and indolent students, then vocabulary made the greater contribution by far and the predictions for achievement from the vocabulary scores for each of the three groups were higher than for any other arrangement. In other words, to get the highest possible prediction for English achievement, the best method is to divide the group into an industrious, a normal, and an indolent group and then predict English achievement separately for each group from the vocabulary scores. Incidentally, of the three groups, the best prediction for achievement in English was made by the industrious group.

Similarity to Social Habits

This finding that the predictions of achievement in English could be predicted much more accurately for the industrious group than for any other group is remarkably similar to the results obtained by Hartshorne and May (2) in their studies of social habits such as honesty, truthfulness, and morality. They found that if a man possessed the more desirable qualities, in general, he was apt to be more consistent. If, on the other hand, he possessed the more undesirable qualities, in general, he was apt to be more inconsistent. The man who is generally honest is also consistently honest, which means that he is dependably honest, whereas the man who is generally dishonest is apt to be inconsistent—he may be honest in one situation and dishonest in another.

A similar investigation was made for mathematics (7) to find the relative contribution of mathematics aptitude, and an index of industriousness for mathematics, to achievement in mathematics. The results for mathematics paralleled very closely those for English. The only exception was that correlation coefficients for mathematics were lower than were those for English, due to using instructors' grades instead of an objective examination. Otherwise, the general conclusions were the same.

Independence of Work Habits

These investigations naturally brought up the question whether work habits were specific or general. That is to say, whether it would follow that a student who was industrious in mathematics would also be industrious in other subjects. The same group of 308 sophomores was used by Krathwohl (8) to investigate the independence of the indexes of industriousness for English, chemistry, mathematics and physics. Out of the 6 pairs that it was possible to form from these four subjects, it was found by means of the chi square test that 5 of the pairs were independent of each other.

The sixth pair, chemistry and mathematics, were found to be dependent on each other. However, when correlation coefficients were computed for each pair, the correlation coefficient between the indexes of industriousness for mathematics and chemistry was found to be only 0.35, yet statistically significant. Such a low but significant value of the correlation coefficient means that a relation does exist but it is a small one. All of the remaining five correlation coefficients were, as expected, much lower and none of them were statistically significant. The conclusion to be drawn from this investigation is that a student can at one and the same time be industrious in mathematics, normal in English and indolent in physics.

Again these results follow very closely those obtained by Hartshorne and May (2) in their studies of social habits such as honesty, truthfulness, and morality. They found that these social habits were specific instead of general. That is to say, we cannot speak of an honest man, but rather of an honest act. For instance, a man may be honest in his income tax returns, but dishonest when he fails to return to the lost and found bureau an article which he has found. In like manner, we cannot speak of an industrious individual, but rather we must say that an individual is industrious in some one area of activity, whereas he may be indolent or normal in another.

The slight dependence between work habits of mathematics and of chemistry demands further investigation, possibly a repetition of the experiment on another group of engineering students.

Before drawing conclusions which are too general it should be remembered that all of the students in these studies were engineering students, who are known to have quite different characteristics from other pre-professional students, as shown by Fairbairn (1). For instance, she found by means of a questionnaire that 36 per cent of the pre-law, 29 per cent of the pre-medical, but only 7 per cent of the pre-engineering students indicated that as children they had liked to dress up for parties, whereas 13 per cent of the pre-law, 16 per cent of the pre-medical and 72 per cent of the pre-engineering students replied that they liked to talk with their inferiors. Hence, further investigations on the properties of these indexes should be made on other types of students, particularly those from liberal arts colleges.

The theory of work habits as outlined in this article has certain weaknesses and certain advantages. The principal weakness in the theory is that with the usual commercial tests the spread of scores of the achievement and aptitude tests, which are used to measure the indexes of industriousness, are approximately equal. Hence, the brightest students in a group cannot get a higher index of industriousness than zero, and the least able students cannot get one less than zero. The simplest method to overcome this weakness of the equality of the spread of scores is to make the difficulty of the initial achievement test sufficiently great so that the spread of scores of the initial achievement test will be greater than that of the aptitude test. There are other methods which can be used to measure indexes of industriousness for students in the extremes of the frequency distribution for aptitudes, but they are more complicated.

Ease of Securing Information

The great advantage of the present theory is the ease with which a counselor can secure information concerning the work habits of a student from his test scores. Making two assumptions, (1) that the theory for indexes of industriousness holds for other subjects in addition to those already investigated, and (2) that the scores which a counselor uses are local ones with equal means and standard deviations; then all he has to do is to pick out an achievement test and an aptitude test and, by simply finding the difference between the two scores, he can ascertain if a student is industrious,

normal or indolent in a particular subject, and the degree to which a student possesses these traits.

The following conclusions can be drawn from these investigations:

1. By means of aptitude and achievement tests in some field, it is possible to assign a number to an individual which will measure his industriousness or indolence in that field.
2. It is possible to show statistically that work habits do affect achievement. Such a statement means that, in general, other things such as level of brightness being equal, the harder a student works, the higher his grade will be.
3. There is a tendency for industrious and indolent work habits to persist certainly over as long a period as two years. Such information should be particularly valuable to counselors.
4. Work habits tend to affect the ability of a student to remain in college. For instance, no matter how bright or industrious a student in the experimental group might have been in his engineering subjects, if he had a small vocabulary and was indolent in English, he was unable to survive through his sophomore year. Similarly, no low ability indolent student in mathematics was able to survive through the freshman year.
5. Work habits of industriousness act very similarly to the social habits of honesty, truthfulness and morality, which were investigated by Hartshorne and May, in that they are specific instead of general, so that a person who is indolent in one field may not necessarily be indolent in another. In particular, a person may be industrious in mathematics normal in English and indolent in physics.
6. Work habits of industriousness also act very similarly to social habits, in that the possession of desirable qualities is accompanied by increased consistency and predictability, whereas the possession of undesirable traits is accompanied by inconsistency and reduced predictability.

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Graduate Work in Machine Design*

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Before attempting to write specifications for a graduate program in Machine Design, let us first review the objectives of the usual undergraduate course. Undergraduate Machine Design is the one subject which makes use of all previous courses. It is, perhaps, the first opportunity the student has to see his educational puzzle begin to fit together. In Machine Design he can see the why of descriptive geometry at the same time that he sees the effectiveness of calculus, and he begins to realize that a knowledge of statics and dynamics is a "must." He finds that strength of materials and metallurgy go hand in hand and that fluid mechanics has more use than the mere satisfying of college degree requirements. In Machine Design the student learns that a firm theoretical core is necessary but that he must surround that core with a ring of practicality and that his work will be for naught if his design cannot be built or will not operate. He learns that there are times when rough approximations are more desirable than rigorous analytic solutions and that there are others in which a compromise may be costly and even disastrous. He discovers that in Machine Design there is no "right answer," for no machine exists that cannot be improved; but he finds that there are certain limits between which he must operate and that more often than not, cost will dictate where he must stand between these limits.

Subject-wise, the student meets nothing new in Machine Design. He simply applies what he has already learned. Briefly speaking, undergraduate Machine Design gives the student an opportunity to view his mechanical engineering as a whole instead of in parts. To be still more brief, in Machine Design the student begins to be an engineer.

Who Should Take Graduate Work

Having begun to be an engineer, the student should next have an opportunity to be one. No young man who hopes to be in the design business should take graduate courses *about* design without first having been *in* design. With some experience behind him, the young designer is in a better position to know what kind of advanced study he wants or whether or not he needs more academic work at all. Not all design is analysis and not all designers can be improved by a college. An SR4 strain gage is no substitute for ingenuity, and the practical know-how of a die designer cannot be enhanced by elliptic integrals. We will probably all agree that ingenuity, while it can be developed, can never be taught and that "know-how" cannot be compressed into a three-hour course.

Graduate work in Design has then, by common consent, become analysis. This means that only analysts or men who could profit by analysis should be in our

* Presented before the Mechanical Engineering Division at the 59th Annual Meeting of the ASEE, East Lansing, Michigan, June 29, 1951.

graduate schools. Rarely does one find a man who enjoys analyzing a machine's characteristics who is also willing or able to spend much time inventing something to analyze. How many ways to make a "widget," pick it up, turn it over, fold it or package it—do not, it seems, go along with a desire to work with pounds per square inch horsepower, feet per second or Reynold's numbers.

We conclude therefore that graduate work in Design is for men with some experience † not boys with "graduate-schoolitis," and that the men are interested in and will be associated with analysis. Knowing the type of individuals with which we have to deal, the next step is to examine their educational backgrounds and provide a program which will fill their needs.

What Background Is Essential

The mechanical engineering graduate enrolling in a Machine Design Master's program may be expected to have the following undergraduate training in pertinent subjects:

One year of engineering mechanics, including statics and dynamics.

One-half year of strength of materials, including laboratory.

One-half year of kinematics of machines.

One year of design of machine elements.

Mathematics through differential equations.

One year of thermodynamics, of chemistry, and of electricity.

Graduates in other engineering fields or those having deficiencies in any of these subjects would be required to make them up before being admitted to graduate standing. This list is not unduly restrictive when compared with current mechanical engineering curricula. It is rather a minimum requirement which attempts to balance reluctance to start at too low a level against the desire to include, for example, an electrical engineering graduate whose objectives have been modified by his work. Most mechanical engineers who have studied machine design would have more than met the specification.

Scope of Program and Course Content

The requirements for the Master of Science degree ordinarily include approximately 30 credit hours of study beyond the Bachelor's level including a six to ten credit hour thesis.

In Machine Design the Master's program should offer the student, recognizing tha he is primarily a coordinator and user of technical information rather than a discoverer, an opportunity to consolidate and extend his knowledge, rather than an intensive study of a specialized area.

In view of this objective, the value of a research thesis which uses a large portion of the student's program should be carefully weighed. For the student with minimum preparation, additional courses would probably be more valuable.

The core of the mechanical designer's problems—determinations of force, stress, deflection, wear, motion, vibration—lies in the realm of Mechanics. The course work should, therefore, give the student further study in Strength of Materials and Elasticity, in Kinematics and Dynamics including vibration problems, and in Experimental Stress Analysis. It should also leave him some time for diversification—indeed this should be required—and perhaps some to pursue a particular interest. Courses in materials properties and fabrication—metallurgy and chemistry should be useful, as well as electricity, heat-power, industrial engineering, and servo-mechanisms.

A typical program for a candidate having minimum preparation follows:

† During the 1950–51 year the Machine Design Division at Case served 46 graduate students representing 30 Cleveland industries.

1. *Vibration Problems:*‡ A three or four hour course in vibrations in linear mechanical systems using a text such as Den Hartog, Timoshenko, Thomson, or Freberg and Kemler.

2. *Advanced Strength of Materials:*‡ A three hour continuation of the elementary course taking up the various methods of computing beam deflections, strain energy methods, elastic stability and column action and three dimensional stresses and strains at a point.

3. *Kinematics and Dynamics of Machines:* A four hour critical survey of basic kinematics and dynamics, preferably using the methods of vector analysis and graphical procedures, and their applications to machine analysis. Topics include static and dynamic force analyses, inertia in rotating systems including gyroscopic effects, critical speeds, and cam dynamics.

4. *Problems in Machine Design:* A four hour course illustrating analytical technique in a variety of design situations. The problems are selected to fill gaps left by the other courses and generally stem from the instructor's experience. Subject matter includes hydrostatic and hydrodynamic lubrication with special emphasis on internal combustion engine bearing design; determination of reciprocating engine rod and main bearing loads; involute trigonometry as applied to gear design and the practice of pyramiding, and to involute splines and measurements for inspection; a thorough study of the ASME Shaft Code for the purpose of reviewing strength of materials with an application to the design of a toggle type impact extrusion press; stress and deformation studies of parts made at room temperature but used at both high and low extremes; fluid couplings and torque converters with emphasis on the matching of a converter to an engine—etc.

5. *Applied Elasticity:* A three hour course using the second volume of Timoshenko's "Strength of Materials" as a text and including the subjects of beams on elastic foundations, bending of thin plates, curved beams, torsion, and contact stresses.

6. *Experimental Stress Analysis:* A four hour course in the most important experimental methods, including two and three dimensional photoelasticity, brittle models and lacquers, mechanical and electrical strain gages, and membrane analogy method. The importance to machine designers of the use of electrical methods for force and vibration measurements is to be emphasized.

7. The remainder of the student's program is composed of either thesis or course work and is arranged in consultation with his advisor to serve best the student's objective. This might include a minimum of eight credit hours for the student with minimum preparation to a maximum of about fifteen hours by one who had majored in machine design as an undergraduate, and who might have taken as senior electives either Vibration Problems or Advanced Strength of Materials, or both.

It is evident that the minimum preparation student, to obtain the desired diversification, should schedule course work rather than thesis. These courses could be chosen from a list similar to the following:

Advanced Heat Power Analysis,
Electronics,
Machine Analysis,
Mechanical Analysis of High Temperature Machinery,
Metals and Alloys,
Methods Engineering,
Physical Metallurgy,
Plastics,
Servomechanisms or Automatic Controls,
Statistical Quality Control.

The better prepared student might be permitted to elect a thesis as part of his program. A flexible policy with regard to length of the thesis project is sug-

‡ Open to undergraduates majoring in Machine Design.

gested. Problems might be rated at from three to nine hours credit based on the faculty advisor's estimate of the amount of work required.** Thus, one student's program might call for a nine hour thesis, and another's (a student who would benefit more from course work) for a three hour thesis and two courses.

Advanced mathematics as such has been purposely omitted. Mathematics courses will certainly do the student no harm but it is our feeling that the type of student who is interested in Machine Design is more receptive to applied mathematics. He learns something tangible about differential equations, about matrices and elliptic functions from his courses in vibrations, elasticity and design problems, and about vector analysis from his work in kinematics. However, we believe that Advanced Calculus should be a part of the Master's program in Applied Mechanics.

M.S. in Applied Mechanics

The difference between the Machine Design course and a program leading to a Master's Degree in Engineering Mechanics is the diversification of the former. While both include some of the same courses, the Engineering Mechanics program is a more specialized one. It should include a year of Advanced Calculus and one term each of Theory of Elasticity and Plasticity, and by all means a thesis. The Engineering Mechanics major is a specialist whom the machine designer among others consults when necessary. For him we propose the following:

1. *Advanced Calculus:* One year's work (2 semesters, 3 hours each) including a review of fundamentals, infinite series, Gamma, Beta and Bessel functions, introduction to vector analysis, complex variables and partial differential equations. Wood's "Advanced Calculus" is probably a suitable text.

2. *Vibration Problems:* A three or four hour course the same as the one recommended for the Machine Design man.

3. *Theory of Elasticity:* A three hour study of the mathematical theory of elasticity, general properties of stress tensor and strain tensor, two dimensional problems solved by Airy's function, elementary three dimensional problems, etc.

4. *Theory of Plasticity:* A three hour course covering the mathematical theory of plasticity; the laws of plastic flow, plastic flow in thick walled sphere and thick walled tube; plastic torsion, bending, etc.

5. *Thesis:* An individual research problem worthy of nine credit hours.

6. The remaining credit hours to be selected from such courses as—

Advanced Engineering Dynamics
Applied Elasticity
Experimental Stress Analysis
Theory of Plates and Shells.

Summary

We have shown that a Machine Designer is inherently a practical person who uses rather than discovers technical facts. Although he may be called upon to be both analyst and inventor, he is likely to be better at one than the other, and he has been in the business long enough to know which he prefers. We have shown too that graduate work is best suited to the needs of the analyst but that the type of analysis is diversified. Thus it is necessary for a mechanical designer to know something about a great many things, which distinguishes him from his close relative the "applied mechanics major" who knows a great deal about a few of the designer's problems.

** If thesis credit is given on an estimated time of $3 \times 15 = 45$ hours work per hour of credit, small problems could be assigned with credit from one hour up, and would include a written report. Only theses carrying six or more hours of credit would be bound and stored in the school library.

Discussion

By VENTON L. DOUGHTIE

Professor of Mechanical Engineering, University of Texas

I first would like to express my thanks to Professors Slaymaker and Wright for putting in print their ideas as to what "Graduate Work in Machine Design" should be. This is a topic which has many ramifications. To have found two people to co-author a paper on this subject is indeed a milestone in machine design education. I remember back in the early thirties when the late Professor F. L. Eidmann of Columbia University was editor of the *Machine Design Bulletin*, *Advanced Machine Design Courses* were considered for two years. All of us entered into the discussion, but no definite conclusions were reached.

For the most part I agree with Professors Slaymaker and Wright, but there are a few ideas which I would like to inject into the thinking. The authors' statements that, "Undergraduate Machine Design is the one subject which makes use of all previous courses" and "Subject-wise, the student meets nothing new in Machine Design. He simply applies what he has already learned" are well written. But I fear that our fellow staff members in Mechanical Engineering would not necessarily always agree to these statements. Often the Machine Design course is looked upon as a dull course in a drawing room where formulas and catalogues are used to obtain "a machine" so that the student can make drawings. In our design courses, the making of elaborate drawings has been reduced to a minimum, drawing-room equipment is used as a means of obtaining results, and experimentation is often necessary to get an essential machine element.

It would certainly be desirable for the graduate student in design to have some experience in this field before graduate study. I think any student would do better graduate work in any subject if he first had some experience; but those of us from state supported schools cannot prevent the student from continuing his graduate study immediately after receiving his baccalaureate degree. Therefore, a graduate course of study must be provided for this type of student. With the increased amount of knowledge apparently necessary for the young engineer, it might not be too far amiss for him to do graduate work in Machine Design immediately after obtaining his first degree. Most of the courses, which Professors Slaymaker and Wright suggest for graduate students in Machine Design, could be as well handled by the recent graduate as the individual who has spent some time in industry. Some phases of the work could be more easily mastered, because the recent graduate would have his fundamentals more readily in mind. Included in this group would be Vibration Problems, Advanced Strength of Materials, Dynamics of Machines, Applied Elasticity and Experimental Stress Analysis. The recent graduate could receive a great deal of benefit from the course, Problems in Machine Design, provided the course contained practical as well as theoretical applications. I would also like for the student to have courses in Physical Metallurgy, Servomechanisms and Production. It is probably true that ingenuity cannot be taught and that "know-how" is absolutely necessary, but I believe that a student who has the interest for graduate design study could and should be taught how things are made, tool and machine limitations, cost analysis, and how America makes a living. There is no substitute for practical experience, but a course on Production taught by a man with some production experience and a design background, can be beneficial to the person going into the design field.

I do not agree with the authors that course work may be substituted for a thesis. Perhaps this might be justified in the case of the person with considerable design experience. The library work in determining what is known about a subject gives the student essential training. The analysis of the problem to determine the factors involved, their interrelationship, and the procedure for test is design at its best. Planning the test set-up and building a part of it teaches such important lessons as: how it is constructed, whether or not it functions properly, can it be built economically, and is it better than other possible mechanisms designed for the same purpose. The experimentation, probably the first without a complete set of instructions, and the determination of the results will not only bring out the fact that theory and practice do not always agree, but that test results are sometimes unpredictable. Then finally the production of a thesis is an experience in the writing of an engineering report or technical publication that is invaluable. It takes time, and often there is not a definite contribution to the knowledge of the world, but sometimes negative results are useful. I believe six hours credit is sufficient for the master's thesis.

To briefly sum up my thoughts, (1) I would not limit graduate work in machine design to only those who had experience in design; (2) in addition to the analytical courses, I would include courses on Production, Metallurgy, and Servomechanisms; (3) in the so-called Advanced Machine Design Course, I would include some practical problems which would tease the student's ingenuity; and (4) I would require a thesis.

College Notes

Antonio Ferri, a pioneer in flight at speeds exceeding sound, who came to this country during World War II, to take part in the war effort under the auspices of the Office of Strategic Services of the U. S. War Department, has been appointed Professor of Aerodynamics at the **Polytechnic Institute of Brooklyn**, it was announced yesterday by Dr. Harry S. Rogers, president of the Institute.

. . .

A new professorship in metallurgical engineer has been established at **Carnegie Institute of Technology** through a grant from the Jones & Laughlin Steel Corporation, according to a joint announcement today by Carnegie President J. C. Warner and Admiral Ben Moreell, president of Jones & Laughlin. The new chair, supported by a grant of $15,000 per year, will be held by Dr. Gerhard J. Derge, professor of metallurgical engineering and a staff member of Carnegie's Metals Research Laboratory. Part of this sum will be used for research and equipment.

Mathematical Engineering Analysis

By RUFUS OLDENBURGER

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Industry is placing increasing emphasis on engineering analysis, namely, the mathematical treatment of engineering problems. Engineering analysis involves the setting up of physical systems in the form of mathematical equations, generally differential equations, and the solution of these equations. The problem of solving the equations is the concern of many courses in mathematics and some of the newly created ones on computing machines. Many fine textbooks are available on these subjects, and they are often well taught. Instruction in the setting up of equations is a more difficult matter. Although this is one of the aims of any engineering curriculum, and the student will learn something about this from his regular engineering courses, the engineering graduate is generally ill equipped to step into industry and predict the performance of equipment, except for a few devices in which he has been especially trained. Thus the mechanical engineering graduate may know how to calculate the characteristics of a steam turbine of a particular type by methods worked out by others who were able to write down the equations, but may be completely at a loss to calculate the performance of a rocket for which equations have not been worked out by someone else, or for which a pattern of calculation has not been established. Even though the equations for a device have been worked out, one often does not have the time to look them up.

As labor and materials have become more expensive the necessity for analyzing equipment to avoid building something that will not work has increased considerably. Because engineering devices often involve components from all of the major fields of engineering, the engineer is being called on more and more to analyze components in other branches than his specialty. Thus an electrical engineer may design a solenoid valve for controlling gasoline flow, and will need to know some hydraulic theory to study the valve. Large manufacturing establishments may have a hundred or more people whose principle task is engineering analysis. These people are sometimes mathematicians and physicists, but more often engineers with a little more training in mathematics and physics than the average engineering graduate. Although large corporations can afford to have members who devote their entire time to engineering analysis, it is necessary for the average engineer concerned with research and development to make his own analyses. The demand for courses devoted entirely to this subject has therefore increased considerably in the last few years. For this reason the author introduced a four semester hour course in engineering analysis both at the Illinois Institute of Technology and De Paul University, designed for seniors and graduate students, along the lines to follow.

Although the subject deserves more attention than one course will allow, the tightness of present engineering schedules makes it advisable to begin a curriculum in engineering analysis with one course only, running over one semester. Although it is desirable for students to

have had some contact with differential equations and advanced calculus, these are by no means necessary since whatever the professor needs from these subjects he can supply, or will have to review anyway.

Course in Formulating Engineering Problems

A course in the setting up of engineering problems in mathematical form should have at least the following major objectives. First, as far as possible the student should be taught a logical, rigorous mathematical picture of the domains of engineering to be covered, so that the student will see just how the laws he uses to set up a particular problem fit into the basic theory of the field. In this way he can better appreciate the limitations of these laws, and select the ones to be applied.

Secondly, the student should be taught various principles for setting up equations. These principles are concerned with the technique of setting up equations, rather than the mathematical laws used. Such principles are often assumed implicitly by the analyst, but may not be obvious to the initiate. For example, if an analyst has set up his problem by neglecting certain factors, he can introduce these factors individually. If his results in each case are unchanged, he may suppose with confidence that if he introduced these factors simultaneously his results would be unchanged, whence his neglect of all of these factors in his initial analysis is justified. It is the author's experience that such principles can well be taught during the solution of practical problems so that these principles take on immediate everyday significance.

Thirdly, the student should be shown how a wide variety of frequently occurring practical problems are set up to a precision needed in industry. The equations so obtained should be as simple as possible because the efficient treatment of a problem generally implies the derivation of a simple set of equations whose solution can be obtained with a minimum amount of effort to no more accuracy than is required for the problem, or allowed when unknown factors are considered.

Division of Subject Matter

In a one semester course on the setting up of equations for physical systems it is not possible to cover all of the major branches of engineering. One solution is to treat the mechanics of particles and rigid bodies, fluid mechanics, heat, and electrical engineering. A possible division of subject matter is the following.

Mechanics—5 weeks (20 hours)

Mechanics of particles	1 hour
Mechanics of rigid bodies, especially linear motions	4 hours
General treatment of forces which occur in nature	1 hour
Review of ordinary linear differential equations	2 hours
Applications to engineering problems in linear motions and methods of making simplifying assumptions	4 hours
Theory of rotational motion about an axis	1 hour
Problems involving rotations, and combinations of linear and rotational motion	3 hours
General principles for setting up mechanics problems	1 hour
Dimensional analysis with applications to mechanics problems	3 hours

Fluid mechanics—3 weeks (12 hours)

Basic equations of fluid flow (force, continuity, and energy)	
Applications to flow of liquids (such as water)	4 hours
Theory and applications to aerodynamics	2 hours
General principles for setting up fluid mechanics problems	1 hour
Dimensional analysis applied to fluid problems	2 hours

Heat—3 weeks (12 hours)

Laws of thermodynamics	3 hours
Applications to thermodynamics problems (such as the flow of gases)	3 hours
Laws of heat transfer	2 hours

Applications of heat transfer theory	2 hours
General principles in the analysis of heat problems	1 hour
Dimensional analysis applied to heat problems	1 hour

Electricity and magnetism—3 weeks (12 hours)

Commonly applied laws (such as those of Kirchhoff for networks and Faraday for induced electromotive force)	5 hours
Applications to engineering problems	5 hours
General principles in the analysis of electrical and magnetic problems	1 hour
Dimensional analysis applied to electrical engineering problems	1 hour

The remainder of the course can be alloted to tests, discussion of problems, and the final examination.

The portion of the course devoted to mechanics can be given in a completely logical, rigorous manner, on the assumption that the student has the mathematical background in hand. Because mechanics is so basic to all engineering, and can easily be taught in a logical way, it is desirable to devote a fair portion of the course to this subject. Except for a few notions which must be borrowed from the theory of elasticity, the subject of fluid mechanics can also be taught in a completely logical manner in a reasonable amount of time. This is not true of the subjects of heat, electricity, and magnetism. Thus in heat transfer the proof of the Stefan-Boltzmann radiation law is much too involved to be included in the course. Further, it is not possible to treat properly the theory of electricity and magnetism in completely logical detail, and it will therefore be necessary to explain the meaning of the laws, and leave the details to be filled in by the student at his leisure.

In the course described above the professor can give the student some background in the rapidly developing field of engineering analysis, teaching him basic principles and giving him considerable practice in the setting up of a wide variety of engineering problems in mathematical form.

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ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Bibliodynamics Laboratory

By GEORGE S. BONN

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The most expensive single piece of laboratory equipment in almost any engineering school in the country is its science-technology research library. Besides being expensive, it is relatively complex in theory, fairly complicated in construction, sometimes baffling in operation technique, frequently difficult in interpretation of results obtained, and always dangerous to misuse. It is a sensitive, though not necessarily a delicate, precision instrument—a well-designed and finely-engineered mechanism. Yet, how much real training in its use do students and research workers (and faculty, for that matter) get in the course of their college careers? Precious little, judging from information available in engineering college catalogs. (Columbia, of course, has been the perennial exception.)

A well-stacked research library with long runs of journals and an extensive collection of current reference books cannot be duplicated these days for much less than $15 a volume, all things considered. Just take a look at any of the periodical catalogs that are sent out from time to time by the various dealers in back sets of research journals, if you don't believe it. A pertinent example of cost might be this one: The median size of 31 engineering departmental libraries within university libraries, according to an Engineering School Libraries Survey in 1948–1949, was 13,000 volumes, and the sizes of the 31 libraries ranged from about 2000 to over 63,000 volumes. The replacement value of this median library today would be close to $195,000, no small sum in anybody's budget. And there are a good many excellent research libraries that are many times larger than this median departmental library.

Yet, every day scores of complete (or almost complete) novices, tyros, and fledgling research workers are turned loose on this expensive and defenseless piece of equipment in almost every school in the country.

Bibliocomplexes

There have been volumes written about the three-dimensional character of the inter-relationships between segments of the world's knowledge and about the problems of applying such a three-dimensional classification system to a two-dimensional book classification scheme so that books, in libraries for instance, can be shelved in a linear arrangement. There are volumes on the principles of cataloging books according to subject matter within this required two-dimensional system, just one of numerous cataloging problems confronted in every library.

Another time-consuming problem, both to the cataloger and to the subsequent library user, is the little matter of catalog entries. Briefly, the philosophy of cataloging is based largely on the admonition to render unto Caesar those things that are Caesar's; the only catch is in being mighty sure of your Caesar. For instance, the official journals, bulletins, transactions, proceedings, and the like of learned and professional societies are always cataloged (and listed) under the names of the societies, unless the publications have more distinctive titles. But most other publications come under their

given titles. A small point, perhaps, but knowing a little bit about the theory behind this apparent chicanery will save the library user many moments of maddening frustration. And there are other bibliocomplexes founded or confounded on what seems to be sheer caprice on the part of the librarians; these have a way of popping up at the most awkward times as the users of our libraries discover for themselves through nothing better than personal perseverance.

The very construction of the library presents difficulties to most users; not only the construction of the building itself but also the construction of the catalog and of the system for shelving periodicals, to mention a few. Older libraries have construction problems that are present in absolutely nothing else but in older libraries. For one thing, they all have edifice complexes. They are usually modeled after some Gothic pile, a chapel or an Old English dining hall or something else equally inspirational. There is hardly a functional stone in them and the one ray of light that slips in through each slim medallioned window does little to guide the weary searcher in his quest for truth. If the stacks are open and there is enough light to see by, the quester may find that bound periodicals have a shelving sequence entirely independent of everything else, based either on some alphabet or on the individual size of each journal. Even more recently-built libraries have the double standard in their shelving procedures, large volumes being arranged in a separate sequence from the one in which the ordinary-sized or small volumes are shelved. And the construction (or division or arrangement or what have you) of the card catalog, the real key to the library's treasures, is at times so baffling as to preclude even the most rudimentary search without some initiation into its mysteries.

Where to attack a room full of reference books, encyclopedias, handbooks, index services, abstract services, dictionaries, and several card catalogs is a decision that even the most hardy and ingenious soul at times finds difficult to make. Without an intelligent S.O.P. or more luck than might be reasonably expected, the hopeful novice is simply stopped in his tracks. Operation Killer seems tame in comparison with Operation Library, to our particular hero at any rate. Not knowing where to attack first our Don Quixote turns his lance on—yes, you guessed it—the person seated behind "the desk," the only one who looks at all official.

The neophyte seminar student or fledgling research worker tracking down references reminds one of nothing so much as a sad-eyed bloodhound. With 3 by 5 cards full of hieroglyphics, numbers, signs, letters, and punctuation marks, he tries his best to pin down the elusive bit of information he hopes to have verified. He surmises, he guesses, he cusses, he follows tips, he flips pages, he pounces upon clues until finally he wears out his patience and calls down a pox on the whole business. Getting a cardful of references to be unearthed is one matter, but interpreting them is quite another more often than not. Experience is, indeed, a hard master.

Now, it must be recognized that these bibliocomplexes and most others that library users come up against are part and parcel of any good science-technology research library that covers any appreciable portion of the world's knowledge, just as complex mechanisms and complicated scientific theories are part and parcel of any piece of laboratory equipment that is used for more than a foot rule. The tyro in any science or engineering lab is on a par with the novice in a science-technology library; both are confronted with what has come to be known as the innate cussedness of inanimate objects. Engineers are constantly working on the simplification of both machinery construction and machinery operation; so, too, are librarians working on the simplification of library construction and library operation. (Paradoxically, both engineers and librarians are build-

ing, at the same time, more and more complicated devices to do more and more complicated operations on more and more complicated problems that have arisen because of our ever-increasing accumulation of knowledge!)

Among the several purposes for laboratory instruction in one of the engineering departments at Northwestern University, for instance, are these: "To acquaint the student with machines and instruments and their use in engineering testing," and "To develop resourcefulness in setting up the apparatus, abstracting the pertinent data and drawing sound conclusions therefrom." In the first lab course in this department, some 50 per cent of the time is spent directly on instruments and testing, and another 20 per cent of the time on instrument and machine construction. In beginning courses in other engineering labs up to 60 per cent of the instructor's time is spent on instruction in the use of equipment and attendant ramifications. These same percentages hold true in many other schools, too, no doubt. In every case, intensive training is given the student at the time he most needs it: when he is first confronted with the problem of actually using the equipment for its intended purpose. It is then that the training is necessary both for the preservation of the equipment and for the education of the student; the training will sink in when the student appreciates its significance.

Bibliotechnical Training

It can be said with a great deal of truth that freshman English courses or freshman engineering-orientation lectures introduce the new students to the library. Unfortunately, however, the student has no continuing interest in the library more than that which might be required for him to write the term paper for English 101; the library, if it's a decently quiet and properly lighted one, becomes thereafter a place to: (1) study homework, (2) rest, (3) get dates, (4) read the newspaper, or, though rarely, (5) look at pictures in engineering magazines. Three or four years later after any inkling whatsoever of what the library can do for the student has long since disappeared, our junior or senior gets his comeupance in an undergraduate (or even graduate) seminar or a literature survey course. Having once heard about the library as a freshman he is turned loose in it with great expectations, but with what disastrous results.

And it can also be said with truth that many high schools have excellent library training in certain courses. So do they have excellent manual training and mechanical drawing and chemistry and physics courses and labs. But the difference between what the student gets in high school and what he gets in college is, to say the least, appreciable, even though the courses have similar subject approach. And the difference between a high school (or a branch public) library and a good science-technology library is also appreciable. It should be noted, though, that good library habits learned at the impressionable high school age seem to stand the student in good stead for quick assimilation of research library techniques later on.

It is true that most subject literature or seminar courses allow an hour or so on "the important sources of information" (or some such wording) in the particular field under consideration before the student is sent on his merry way. The results are about the same regardless of when the student gets his library briefing: the library staff gets each student individually and gives him just such information as the student wants for his immediate problem; the next time the same student will have a different problem, and the next time, and the next, *ad graduation*. These results are inevitable whenever the student becomes interested in a different, though related, field. However useful they are in keeping the library staff busy (and therefore happy because the statistics are going up) these results

are also flagrant evidences of inefficient use of the time of everybody concerned, the student, the instructor, and the library staff member.

There are some who may question the necessity or even the value of more than mere briefing in the proper use of a science-technology library for undergraduate students. If the purpose of engineering education is to turn out mere technicians, intelligent equipment operators, or brilliant slide-rule manipulators, then there is no point in spending more than a minimum time on library introduction. But if the purpose of engineering education is to give students a sound basis for furthering their own ambitions through continued study and interest in the field of engineering and to help students set patterns of scientific thinking that will be useful to them the rest of their lives, certainly they must be acquainted with and have respect for a good science-technology library and they must know how useful it can be in whatever field of work they find themselves.

It should be the purpose of any training in library usage first, to acquaint the student with the technical literature of engineering in general and of his own field in particular; second, to introduce the student to the literature of allied fields of science and to the literature of the social sciences and of the humanities; third, to prepare the student to make an efficient literature search; and fourth, to acquaint the student with the resources of his own engineering school library.

Instruction in the proper use of a piece of lab or research equipment is necessary so that the device may be put to the most efficient use for which it was intended. Machines that are expensive, hazardous, delicate, sensitive, complicated in theory, complicated in construction, complicated in operation technique, or complicated in the interpretation of results all require—and get—expert care and training in their operation. Why shouldn't the science-technology library which is, in its own way, just as needful of proper care and training in its use?

College Notes

Dr. Harry P. Hammond, Dean of the School of Engineering at the Pennsylvania State College, retired with emeritus rank on September 1 and was succeeded by Dr. Eric A. Walker, Director of the Ordnance Research Laboratory and Professor and Head of the Department of Electrical Engineering.

The research program in the School of Engineering made phenomenal gains during Dean Hammond's 14 years at Penn State, and today Penn State ranks among the leaders of all the institutions of the nation in funds budgeted for research conducted by its School of Engineering. Physical facilities of the School have also been expanded with the Electrical Engineering Building, which was started soon after Dean Hammond's appointment, completed in 1939, and the Civil Engineering Surveying camp constructed in 1940 and others.

During his years at Penn State, Dean Hammond won two of the top national engineering awards. In 1945, he was presented the Lamme Award, the top honor in the field of engineering education, while last year he was given the James H. McGraw Award in Technical Institute Education by the American Society for Engineering Education.

In World War II, Dean Hammond served as a member of the National Advisory Committee of Engineering Defense Training and was in charge of the

(*Continued on page 187*)

Thermodynamics for Graduate Students*

By ALI BULENT CAMBEL

Assistant Professor of Mechanical Engineering, State University of Iowa

Teaching advanced thermodynamics to graduate students is more difficult than teaching the basic discipline to undergraduates because for the former there are neither prescribed curricula nor standard texts. The instructor must be the sole and uncertain judge of what and how to teach future thermodynamicists.

In considering the problems involved in teaching of advanced thermodynamics, the first question which may be posed is: To what career does a graduate student specializing in thermodynamics look forward? Probably to scientific rather than production or maintenance work, either in an educational institution or in a research laboratory. The next question is: What is meant by scientific work in the field of thermodynamics? And the answer: Scientific work in thermodynamics is research and development leading to more economical or heretofore unknown conversions of thermal energy. The final question which may be asked is: Is there any need for research in thermodynamics? Definitely, yes. If we consider the depletion of our conventional fuels and resources, the needs of the atomic era, flight at great speeds and high altitudes, to say nothing of the intellectual challenges of the endless frontiers of science, we become convinced that there is definite need both for thermodynamic research and for the development of resourceful thermodynamicists who are able to execute such research development.

The initial training of future thermodynamicists takes place at the graduate level at which objectives for teaching are different from those for undergraduate instruction. In the teaching of thermodynamics to undergraduates the objective is to acquaint the student with fundamental laws and the standard applications of them. With graduate students, the purpose is not to repeat what has already been taught, but to deduce with them the various implications of the fundamental laws, to test the possibility of new applications of the laws, and to lead them to apprehend the logic of thermodynamics. Obviously, therefore, the teaching of future pioneers in thermodynamics will properly be more eclectic than dogmatic.

When the thermodynamicist does scientific work, investigating little known phenomena or developing new devices, how does he conduct his research? Either in some unorganized, trial-and-error way or in an organized and controlled manner. Undoubtedly the latter is preferable, because we can no longer afford to waste time, money, and human lives.

Organized research means, first, that which is based on analytical or empirical justification or on both. The research worker who does not know well the theory of his discipline can produce at best only mediocre work. Helmholtz advised, "There is nothing more practical than a good theory."

Second, organized research means that which is carried on methodically. Investigations in thermodynamics, as in any other field in which the frontiers of

* Presented before the Mechanical Engineering Division at the Annual Meeting of the ASEE, East Lansing, Michigan, June 27, 1951.

knowledge are to be pushed outward, must go through four stages. First, a general phenomenological knowledge of the possible events must be established from laboratory observations or from previous experience. Second, with this rough idea, an analysis should be made to formulate a mathematical expression of the phenomena. Third, this mathematical analysis must be experimentally proved. Many brilliant mathematical derivations do not truly represent the phenomenon described. Only a laboratory test of mathematical predictions can establish their validity. The design of the instrumentation for laboratory measurements as well as the measurements themselves will be determined by the mathematical analysis so the mathematics should be in a form that can be conveniently translated into a material state. Fourth, the data must be organized and from them a theory developed which is valid both mathematically and experimentally. Therefore, organized research in thermodynamics is based on sound justification and proceeds through a cycle of observation, formulation, measurement, and generalization. If this method of systematic study is inculcated into our graduate students we may expect to see some very fruitful work produced.

A Graduate Course in Thermodynamics

With the type and manner of work of the thermodynamicist defined, a method of preparing graduate students for such a career can be proposed. The three credit hours, one semester course which has been offered for the past two years in the Mechanical Engineering Department of the State University of Iowa is open only to graduate students who are working towards the master's or the doctor's degree. The prerequisites are undergraduate thermodynamics, fluid mechanics, and engineering mathematics.

Undergraduate courses in thermodynamics and fluid mechanics are clearly explained in the requirements of the ECPD, but "engineering mathematics" perhaps should be defined as a course beyond the calculus. Most institutions now require such a course, sometimes called "applied mathematics," which, though differing among institutions, usually includes ordinary and partial differential equations, theory of equations and vector analysis.

In our "Mathematical and Experimental Thermodynamics" the approach to thermodynamics is classical rather than statistical, because the mechanical engineer is concerned with macroscopic rather than microscopic systems. The material covered may be outlined in the sequence usually followed:

1. *The Concept of Temperature and the Zeroth Law.* The general mathematical expression for a thermometric scale is presented and the methods of constructing thermometers utilizing various thermometric properties are explained. The possible errors in thermometers are discussed and time lag is considered both analytically and physically. The course is started with thermometry because the student has dealt extensively with the use of thermometers and therefore he is at least on familiar ground when he is first asked to use mathematics and relate it to empirics.

2. *The Equation of State and Thermal Coefficients.* The technique of setting up state equations is demonstrated and the interrelationship of thermal coefficients is explained. It is indicated that thermodynamical coefficients are expressible by partial derivatives. Then the instrumentation necessary for the quantative measurement of these coefficients is described. On the basis of the difficulties of measurement encountered in instrumentation the suggestion is made that it is often convenient to transform an unknown thermal coefficient into one better known or one measured more easily than is the unknown coefficient itself.

3. *Dimensional Analysis.* Though dimensional analysis has been applied extensively in heat transfer and fluid flow, its potentialities have not been fully ex-

ploited in the field of thermodynamics. For instance, work on the applying of the principles of similitude in the designing of internal combustion engines is already being carried on in several institutions. Therefore, this study is very practical. Furthermore, the teaching of dimensional analysis manifests the difference between equations in applied mathematics and those in pure mathematics. Further, it is emphasized that the number of dimensionless products is not necessarily equal to the number of derived units minus the number of fundamental limits.

4. *The Line Integral.* The difference between path functions and point functions is demonstrated and a study is made of the theorems which indicate how a thermodynamical function may be tested for independence of its path. In studying the appropriate theorems their necessary and sufficient conditions are proved, so that the student achieves a better grasp of the mathematical approach to thermodynamics.

5. *The First Fundamental Law.* The first law is approached in accordance with the Poincaré view. This may have been expected from the study of the Zeroth Law. The mathematical necessity for the existence of internal energy is proved, and its being a point function is demonstrated. The fact that the steady flow energy equation is a consequence of the first law and that the first law is not derived from the steady flow equation is particularly emphasized. The enthalpy is introduced and various relations for computing it from other thermal coefficients are derived.

6. *The Second Law of Thermodynamics.* Kelvin's temperature scale is explained and then Clausius' theorem is used to demonstrate that the entropy is a mathematical necessity because it becomes apparent when an integrating factor is found in the converting of an inexact to an exact differential. Relations are developed to define the entropy in terms of quantities which are directly measureable, thus familiarizing the student with the development of thermodynamic tables. The free energy functions of Helmholtz and Gibbs and Planck are discussed in some detail, and it is shown that, like the entropy, they are criteria of equilibrium.

7. *The Third Law of Thermodynamics.* Although Nernst's heat theorem has reached the status of a thermodynamic law it is rather difficult to convince students by means of classical thermodynamics that the integration constant of the entropy differential should be zero at absolute zero. In explaining the third law the approach of Lewis and Randall is followed.

8. *Thermodynamic Functions.* The Maxwell equations are derived both by the method of partial differential equations and by that of analytical geometry.

9. *Functional Determinants.* The fundamental theorems of the Jacobians are proved. It is showed that these must be obeyed in the writing of an equation of state or the unequivocal determination of a thermodynamic state point. Norman Shaw's Jacobian method in the manipulation of thermodynamic equations is discussed and the resulting relations are discussed from the point of view of ease of experimental determination.

10. *Thermodynamics of Fluid Flow.* Vectorial analysis is presented as the thermodynamicist's best technique for investigating fluid flow. The discussion is based on the Eulerian system thus immediately restricting it to isentropic flow. It is showed, for example, that for irrotational flow the entropy must remain a constant. Furthermore, it is indicated that for supersonic flow the characteristic equation must be expressed in hyperbolic form.

11. *Gas Dynamics.* The thermodynamics of gases at high velocities is discussed on the basis of the energy equation, by which losses may be accounted for. The Fanno conditions, the Rayleigh conditions, and shock phenomena are considered. The measurement of flow

quantities by the stagnation tube and the Toepler-Schlieren method are studied as the final topics in the course.

General Comments

To this topical outline of "Mathematical and Experimental Thermodynamics" should be added some general comments:

1. The instruction is not an attempt to teach thermodynamics nor mathematics nor instrumentation, but to show the mathematical and experimental techniques available to the research thermodynamicist.

2. The instruction attempts logically to develop in the student an understanding of thermodynamics by the emphasizing of the interrelation between mathematics and experimentation. The approach is fundamentally mathematical. There is no more simple nor more uninhibited approach to thermodynamic research than that of mathematics. However, experimental checking is continually urged as a salutary rein on the enthusiasm of the theorist. In a crude analogy, mathematics is comparable with the vigor of youth, and instrumentation with the wisdom of experience and maturity. In conjunction, mathematics and instrumentation make up a powerful team; separately, they achieve little.

3. The instruction indicates to the student some of the present limitations of classical thermodynamics and urges that he become familiar with Kinetic Theory and Statistical Thermodynamics. On the other hand it becomes evident that the science of thermodynamics is far from having been exhaustively investigated.

4. By presenting research methods the instruction makes it possible for the advanced student writing a thesis to spend less time developing his techniques and more gathering and interpreting his data.

5. To future teachers of thermodynamics the instruction imparts an insight which can be achieved only by a philosophical approach.

6. No attempt is made to give a physical meaning to mathematical functions like the enthalpy, the entropy and the free energies. However, their importance in studying physical effects is discussed.

7. Research requires the drawing of correct conclusions from feasible assumptions. In other words, it rests on syllogisms which in engineering research are represented by mathematical relations.

This course was instituted to transform graduate students into thermodynamicists who are prepared for their jobs and who can work at them efficiently. The content and methodology grew out of a consideration of the kind of work and the proper method of procedure of a scientist in thermodynamics.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College Hanover, N.H.

THE T-SQUARE PAGE

Officers
C. H. SPRINGER, *Chairman*
R. T. NORTHRUP
T. T. AAKHUS
C. J. VIERCK
J. S. RISING
H. E. GRANT
R. S. PAFFENBARGER

DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

B. L. WELLMAN, *Editor*
Worcester Polytechnic Institute

Officers
J. GERARDI
J. G. MCGUIRE
W. E. STREET
C. E. ROWE
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W. J. LUZADDER

Mid-Winter Drawing Division Program
New York City, January 23, 24 and 25, 1952

The Executive Committee has accepted the invitation of three New York universities to hold the Mid-Winter Meeting of the Drawing Division in that city in January, 1952. The tentative program is as follows:

Wednesday, January 23, 1952
AT THE COOPER UNION

Morning

8:30–10:00 Registration.
Inspection of Department of Machine Design and Engineering Drawing.
Tour of Historic Foundation Building of The Cooper Union for those who desire it.

10:00–12:00 Meeting.
Greetings, Dr. Edwin S. Burdell, President of The Cooper Union.
Welcome from the Engineering School, Dean Norman L. Towle.
Response, Professor Clifford H. Springer, Division Chairman.
"Descriptive Geometry in Ship-building." Mr. Renato Iodice, Naval Architect, Gulf Oil Company, Part-time Instructor, The Cooper Union Evening School.

12:00 Luncheon.

Afternoon

1:00–1:20 Board bus for New York Naval Shipyard.

2:00–4:15 New York Naval Shipyard.
Greetings, Rear Admiral P. B. Nibecker, Commander, New York Naval Shipyard and Naval Base.
Demonstration and Explanation of Lofting in the Mold Loft (developing a shell plate), Lieutenant (S.G.) Dixon, assisted by a loftsman.
Visit to Plate Shop, direction of Commander Fink.
Visit to Dry Docks (if time and weather permit).

5:00 Arrive at The Cooper Union
Open House.

Evening Executive Committee Dinner.

Women's Program
Tours of New York City, visits to Museums and Art Galleries, shopping, luncheon.

Thursday, January 24, 1952
at THE UNITED STATES MILITARY ACADEMY
West Point, N. Y.

Morning

8:30 Leave New York by special bus.

10:30 Arrive at West Point.

11:00–1:00 Men's Program, in Department of Military Topography and Graphics.
1. The mission of West Point.
2. The over-all curriculum and its effect on fulfilling this mission.
3. The part played by the Department of Military Topography and Graphics in in this curriculum.
4. Demonstration of methods used.
5. Exhibition of facilities, teaching aids, etc.

Women's Program

Conducted tour of kitchens, bakeries, cadet mess hall and museum, as time permits.

Afternoon

1:00 Luncheon at Hotel Thayer (both men and women).

2:00–4:00 Conducted tour of West Point Reservation, concluding with a short organ recital in the Cadet Chapel (men and women).

3:00–4:00 Opportunity for members to meet friends or relatives in the Cadet Corps.

4:00–6:00 Return to New York City.

Evening Theatre party. Efforts are being made to reserve a block of tickets for a musical show.

Friday, January 25, 1952
at COLUMBIA UNIVERSITY

Men's Program

Morning

9:00 Inspection of Department of Graphics, 6th floor, Eng. Bldg.

10:30 At Harkness Academic Theatre.
"The Integration of Drafting with the Photographic Process," Lloyd E. Varden, Technical Director, Pavelle Color, Inc.
Discussion.
Second paper to be announced.

12:30 Luncheon. John Jay Hall Mezzanine.

Afternoon

2:00 Trip 1. Special bus to "Nevis." - Inspection of the Columbia University Cyclotron.
Trip 2. Inspection of the photographic color processing plant of Pavelle Color, Inc.

Evening Annual Dinner, Men's Faculty Club, Columbia University.
Speaker: Dr. John R. Dunning, Dean of the School of Engineering, Columbia University.

Women's Program

Morning Guides will be provided for shopping or sight-seeing. Television color broadcast.

Afternoon

1:00 Luncheon.

2:00 Style Show.

3:00 Choice of following trips:
1. Behind-the-scene trip through Vogue publishing offices.
2. Good Housekeeping Institute.
3. McCall Home-Maker Institute.
4. Costume Institute, Metropolitan Museum of Art.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

TIMELY TIPS

Problems Relating to Rolling With Slipping

By S. R. UNIECHOWSKI

Assistant Professor of Engineering Mechanics, University of Detroit

The majority of text-books in Engineering Mechanics in this country, while giving a good selection of problems on rolling without slipping, fail to explain in an adequate manner the method of solution when sliding does occur or is suspected.

The statement: . . . "A homogeneous cylinder (or wheel, or sphere) of radius r rolls without slipping . . ." is taken by the students for granted nearly in the same way as for instance the fact that all bodies in Mechanics are considered to be rigid.

A. Pure Rolling

A homogeneous body (cylinder, wheel, disc or sphere) rolls down a rough inclined plane without sliding. Find the distance travelled in t seconds from rest. Suppose that, at the beginning of the motion, B was in contact with A. C is the point of contact t seconds after the start. Let AC be denoted by x and let r be the radius. Let N by the normal pressure between the body and the plane and F the frictional resistance up the plane. The equations of motion of the mass-center of the body will be:

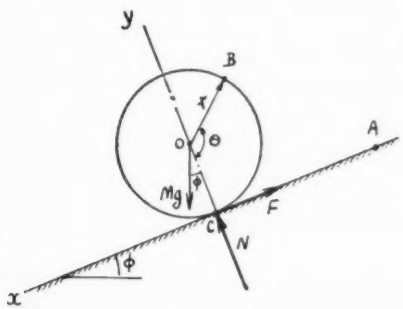

FIG. 1.

$$\Sigma F_x = M\bar{a}_x;\ Mg\sin\phi - F = M\bar{a}_x, \qquad (1)$$

$$\Sigma F_y = M\bar{a}_y;\ Mg\cos\phi - N = 0, \qquad (2)$$

$$\Sigma \bar{T} = \bar{I}\alpha;\ rF = \bar{I}\alpha. \qquad (3)$$

Since there is no sliding AC is equal to the arc BC; that is

$$X = r\theta. \qquad (4)$$

Differentiating both sides twice, we get

$$\frac{d^2x}{dt^2} = \bar{a}_x = r\cdot\frac{d^2\theta}{dt^2} = r\alpha. \qquad (5)$$

Eliminating F from (1) and (3)

$$M(r\bar{a}_x + K^2\alpha) = Mrg\sin\phi. \qquad (6)$$

From (5) and (6)

$$\bar{a}_x = \frac{r^2}{r^2 + K^2}\cdot g\sin\phi. \qquad (7)$$

Integrating twice the last equation the distance travelled in t seconds from rest is thus

$$X = \frac{r^2}{2(r^2 + K^2)}\cdot gt^2\sin\phi. \qquad (8)$$

Equation (1) gives now the friction. Thus

$$F = Mg\sin\phi - M\bar{a}_x$$

$$= \frac{K^2}{r^2 + K^2}\cdot Mg\sin\phi. \qquad (9)$$

B. Rolling and Sliding

A homogeneous body (as in "*A*") rolls and slips down a rough inclined plane. Find the acceleration down the plane $\bar{a}_x$ and the angular acceleration.

When the body is rolling and sliding *the friction is limiting friction.*

The equations (1), (2) and (3) of part "*A*" are still valid. But since slipping takes place the equation (4) is no longer true. Instead we have the equation expressing the fact that the friction is limiting friction.

$$F = \mu_K N, \tag{4}$$

where μ_K is the coefficient of *Kinetic* friction. From equation (2)

$$\mu_K N = \mu_K M g \cos\phi. \tag{5}$$

Substituting this value for F in (1) and (3) and then dividing each by M

$$\bar{a}_x = g \sin\phi - \mu_K g \cos\phi, \tag{6}$$

$$K^2\alpha = \mu_K a g \cos\phi. \tag{7}$$

Thus both the acceleration of the mass-center $\bar{a}_x$ and the angular acceleration α are constant. The motion of the mass-center is entirely independent of the shape of the body when slipping does occur.

The equation (6) is just the same for a body which does not roll at all.

C. Test for Slipping when a Body (as in "A") Rolls Down a Rough Inclined Plane

When a body rolls down a rough inclined plane the motion may be pure rolling or a combination of rolling and sliding and both sorts of motion have to be investigated. Equations (2) and (7) of part "*A*" give

$$\frac{F}{N} = \frac{K^2}{r^2 + K^2} \cdot \tan\phi. \tag{1}$$

But F cannot be greater than $\mu_S N$. Consequently the motion will be a combination of rolling and sliding if

$$\frac{K^2}{r^2 + K^2} \cdot \tan\phi > \mu_S, \tag{2}$$

and will be pure rolling if

$$\frac{K^2}{r^2 + K^2} \cdot \tan\phi < \mu_S, \tag{3}$$

where μ_S is the coefficient of *static* friction.

Before attempting to solve the equations of motion for a body rolling down a plane, it will therefore be necessary to discover which of the inequalities (2) or (3) is true. If (2) is true the results of part "*A*" are correct, but if (3) is true the results of "*B*" must be used.

When sliding occurs the instantaneous center is not at the point of contact C but on the line OC below or above the plane at a distance R from O, such that

$$\bar{a}_x = R\alpha \quad \text{or} \quad R = \frac{\bar{a}_x}{\alpha}$$

($\bar{a}_x$ being now *not* equal to $r\alpha$).

General Remarks

In problems where in addition to the weight of the body other external forces are involved the whole procedure of solution is slightly different.

The direction of the frictional resistance must be assumed first and from the equations $\Sigma F_x = M\bar{a}_x$ and $\Sigma \bar{T} = I\alpha$ the value for F, required for rolling, may be obtained. This value for F must be compared to the maximum possible (available) frictional force obtained from $\Sigma F_y = M\bar{a}_y = 0$. Substituting the later value, if slipping occurs, into $\Sigma \bar{T} = I\alpha$ and $\Sigma F_x = M\bar{a}_x$, the values of α and a_x may be obtained. The negative signs in final results indicate, as usual, that the directions must be reversed.

Minutes of Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Saturday, September 29, 1951, at Cornell University, Ithaca, New York. Those present were: S. C. Hollister, *President,* M. M. Boring, A. B. Bronwell, L. E. Grinter, J. H. Lampe, G. A. Rosselot, C. L. Skelley, and B. Bowen. The meeting was called to order at 9:30 A.M.

Report of the Treasurer:

The report of the Treasurer was presented. Receipts and disbursements were reviewed in the period of July 1 to September 30, 1951 as compared with the first quarter of last year.

Vice President Lampe reported on the plans for the ECAC meeting. The two major topics to be discussed are: (1) adequacy and standards of engineering education, and (2) cooperation between junior colleges, secondary schools, and colleges in matters relating to educational standards, guidance, etc. He requested President Hollister to handle the first topic and will secure speakers for the second topic.

Vice President Rosselot reported that the ECRC has been studying the problem of contract relations with the federal government since June. There have been active conferences in Washington on such matters as equipment procurement problems, contract regulations, patents, etc. The ECRC is attempting to formulate a sound policy embodying desirable features of contract relationships between the federal government and engineering colleges. These problems will constitute the program material for the Houston meeting.

Improvement of Teaching:

Vice President Grinter reported that the Committee on Improvement of Teaching has sent a preliminary report to the chairmen of institutional committees and deans of engineering colleges, asking for comments and criticisms. A small writing committee will be appointed to prepare a final report to be presented at the Annual Meeting at Dartmouth. The Committee is working with the Division of Educational Methods so that in the future the work can be carried on by this Division.

Unity of the Profession:

Dean Saville has requested specific recommendations from the Society on the proposed plans for a Unity of the Profession Organization. At the June 29 meeting of the General Council a motion was passed to the effect that the ASEE should be included in any unity organization and that the Society should cooperate fully in the formation of such an organization, provided that the ASEE as a constituent society can retain its present membership requirements. However, this resolution was not definitive enough to enable Dean Saville to present the recommendations of the ASEE as to the structure of the unity organization. After considering the four proposals prepared by the EJC Committee on Unity of the Profession, the Executive Board expressed preference for some type of organization which would combine the desirable features of Plans A and B. In general, the Council type of organization seemed to be preferred over the individual membership type of organization.

Joint Committees with Organizations of Junior College and Secondary School Principals and Counselors:

President Hollister proposed that the ASEE take steps to set up a joint committee enabling the junior college faculties, high school principals, and voca-

tional counselors to participate with the Society in discussions of problems relating to the adequate preparation of engineering students. He stated that the ASEE could lay the groundwork for real cooperation between engineering colleges, junior colleges and high schools. As a means of initiating this program, it was proposed that three people be invited to attend the Houston meeting for active participation: a member of the Science Teachers Association, a member of the High School Principals Association, and one person from the Edison Educational Foundation. Invitations will also be extended to Admiral Bowen and Mr. Paul Busse of the Edison Foundation to attend the ASEE meetings in Houston.

The Secretary mentioned that a Junior College Committee has not yet been appointed. It was decided to defer appointment of this Committee until the new program of cooperation with Junior Colleges and Secondary Schools has been clarified. It was pointed out that since the Secondary Schools Committee is a Committee of the ECAC, it might be logical to have the Junior College Committee also report to the ECAC.

Suggestions from Society Members for Consideration by the Council:

The Executive Board decided to appoint a committee of members of the General Council to study the problem of setting up a mechanism for more active participation by Society members.

Mailing of American Council on Education Bulletins:

The question was raised as to whether or not the Society should continue to subsidize mailing of American Council on Education bulletins to engineering deans. It was decided to continue this mailing.

Mission on Engineering Education to Japan:

Secretary Bronwell outlined briefly the work of the Mission on Engineering Education to Japan during the past summer. The fifteen members of the Mission, under the chairmanship of Harold Hazen, held meetings in educational centers throughout Japan. The meetings were in the form of panel discussions, with U. S. and Japanese representatives on the same panel. Over 1000 Japanese educators participated in these discussions.

The panel discussions dealt with administrative problems, research policies, cooperation between industry and colleges, improvement of teaching, and specialized topics in various curricular areas. The panel discussion system proved to be very successful in focusing attention upon those problems which were of greatest importance to the Japanese.

The Secretary commented favorably on the progress which is being made in research in engineering colleges and pointed out some of the problems in their educational system, many of which are quite similar to problems in American engineering colleges. A proposal has been made to set up a society for engineering education in Japan comparable to the ASEE. The Secretary stated that extremely cordial hospitality had been accorded members of the Mission by the Japanese educators and that the Mission has served to develop working relationships between Japanese and American educators, as well as a common bond of friendship.

Other Missions on Research and Engineering Education:

It was pointed out that several missions on research and education are being organized to visit European countries. The Executive Board expressed the opinion that the ASEE should be officially represented on these missions. Dr. Rosselot and Dr. Grinter will confer with the proper authorities on methods of getting ASEE representatives appointed to these missions.

Summer School Requests:

The Board approved the requests of the Electrical Engineering Division and

the English Division for summer schools to be held at Dartmouth in June. Details of planning of these two summer schools should be arranged with Dean Kimball by the Divisions themselves. Mr. Boring mentioned that the General Electric Company would like to sponsor a "Methods of Instruction" program during the week after the Annual Meeting at Schenectady in order to familiarize educators with some of the novel methods of instruction used in the company's post-graduate program. The Executive Board approved this plan, details of which will be worked out by Mr. Boring.

Organization of Textile Committee:

The Secretary read a letter from Professor Rogers Finch of M.I.T. suggesting the possibility of the organization of a Committee on Textile Engineering in the ASEE. A motion recommending the formation of such a committee was approved.

Associate Institutional Membership Drive:

President Hollister stated that Mr. Jesse McKeon had been appointed chairman of a committee to approach those industries which are interested in engineering education in order to expand the number of associate institutional members. Mr. McKeon is now getting this project organized.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

College Notes

(*Continued from page 176*)

inspection of Army Specialized Training Program units in the Third Service Command.

From 1924 to 1927, Dean Hammond was associate director of a comprehensive study known as the "Investigation of Engineering Education," which was sponsored by the ASEE. He was an active member of the ASEE, serving as Vice-President in 1934–35 and as President in 1936–37. He was one of the organizers of the Engineers' Council for Professional Development and also helped to organize and served until last year as Chairman of the Council's Committee on Technical Institutes.

Dr. Walker during the period 1942 to 1945 served as research associate, assistant director, and finally associate director of the Harvard Underwater Sound Laboratory, Cambridge, Mass., where he had charge of the development of ordnance weapons. For his work there, he was awarded the Naval Ordnance Development Award and also a Presidential Certificate of Merit.

In 1945, through the efforts of Dr. Walker and Dean Hammond, arrangements between the College and the Bureau of Ordnance, Navy Department, were completed, establishing the Ordnance Research Laboratory at Penn State. Work in the laboratory started on October 1, 1945, and many of the staff members, including Dr. Walker, came to Penn State from the Harvard Underwater Sound Laboratory. Dr. Walker has served as Director of the Laboratory from its founding and at the same time has held the position of Professor and Head of the Department of Electrical Engineering.

Dr. Walker, who was elected last year as a director of the ECRC, has also served as Chairman of the Educational Methods Division of the ASEE.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	Carnegie Institute		E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5 or 12, 1952	R. Z. Williams, Missouri School of Mines
*National Capital Area			W. Oncken, Jr., Bureau of Ordnance
*New England			W. C. White, Northeastern University
*North Midwest			K. F. Wendt, University of Wisconsin
*Ohio	Ohio State University		W. F. Brown, University of Toledo
*Pacific Northwest	Seattle		T. H. Campbell, University of Washington
*Pacific Southwest	Los Angeles San Francisco	April, 1952	S. F. Duncan, University of Southern California
*Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952.	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
*Upper New York	Clarkson College		W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

BLAKEMORE, WYATT D., Instructor in Engineering Drawing, Iowa State College, Ames, Iowa. A. S. Gaskell, S. J. Chamberlain.

BLISARD, THOMAS J., Associate Professor of Physics, Newark College of Engineering, Newark, N. J. C. V. Bertsch, H. H. Smith.

BOWMAN, JOHN J., Director, Bowman Technical School, Lancaster, Pa. K. O. Werwath, S. A. Eng.

BRILL, KENNETH G., JR., Associate Professor of Geology and Geological Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

BROOKS, EDWARD M., Associate Professor of Geophysics and Geophysical Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

BUBB, FRANK W., JR., Associate Professor of Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

BURGER, WILLIAM V., Registrar, Colorado School of Mines, Golden, Colo. F. R. Campbell, G. W. LeMaire.

CLARK, RODERICK D. M., Instructor in Geophysics and Geophysical Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

COYLE, FRANK J., Associate, Bureau of Trade and Technical Education, N. Y. State Dept. of Education, Albany, N. Y. W. H. Branch, F. E. Almstead.

CREELMAN, GEORGE D., Research Coordinator, M. A. Hanna Company, Cleveland, Ohio. C. E. MacQuigg, L. D. Jones.

CRONIN, JAMES L., JR., Assistant Professor of Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

CROWNINSHIELD, WILLIAM W., Head, Mechanical Dept., Franklin Technical Institute, Boston, Mass. R. G. Adams, P. H. Humphries.

DAVIS, CHARLES R., Professor of English, Rutgers University, New Brunswick, N. J. E. C. Easton, M. T. Ayers.

DAVIS, JOHN F., Instructor in Electrical Engineering, University of New Mexico, Albuquerque, N. M. M .E. Van Valkenburg, W. G. Hoover.

DESOUSA, JOSE CARLOS C., Graduate Student, University of Michigan, Ann Arbor, Mich. G. W. Clark, N. S. Waner.

DREIFKE, GERALD E., Assistant Professor of Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

FEIGEN, MORRIS, Associate Engineer, Engineering Dept., University of California, Los Angeles, Calif. C. M. Duke, J. M. English.

FELDMAN, EDWARD S., Instructor, University of California, Los Angeles, Calif. C. M. Duke, J. C. Dillon.

FULLER, H. EDWARD, Instructor in Electrical Engineering, Franklin Technical Institute, Boston, Mass. R. G. Adams, B. K. Thorogood.

HUFF, WILBERT J., Professor and Chairman of Chemical Engineering, University of Maryland, College Park, Md. S. S. Steinberg, R. B. Allen.

HUNT, ROY E., Technical Recruiting Division, General Electric Company, Schenectady, N. Y. C. F. Terwilliger, K. B. McEachron, Jr.

JOHNSON, CHARLES A., Assistant Professor of Mathematics, Missouri School of Mines, Rolla, Mo. R. M. Rankin, R. H. Kerr.

KIMBALL, LEE E., Assistant Professor of Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

KISSLINGER, CARL, Instructor in Geophysics and Geophysical Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

KYBURZ, PAUL H., Instructor in Mechanical Engineering, Michigan State College, East Lansing, Mich. C. C. Sigerfoos, H. L. Womochel.

MARSHALL, STANLEY C., Assistant to Director, Penn Technical Institute, Pittsburgh, Pa. N. P. Bosted, L. A. Dimasi.

McBRIDE, GUY T. ,Assistant Professor of Chemical Engineering, Associate Dean of Students, The Rice Institute, Houston, Texas, W. V. Houston, L. B. Ryon.

McMANUS, JOHN F., Assistant to the Dean, Cornell University, Ithaca, N. Y. W. L. Conwell, R. F. Chamberlain.

MILLER, HOWARD M., Personnel Consultant, Engineering Dept., E. I. duPont de Nemours & Company, Wilmington, Del. R. L. Sumwalt, L. E. Grinter.

PANLENER, GLENN F., Assistant Professor of Mechanical Engineering, New Mexico College of A. & M. A., Las Cruces, N. M. M. A. Thomas, R. E. James.

PILOTTE, FRANK F., Instructor in Geophysics and Geophysical Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

POTTER, CLARK A., Instructor in Engineering, St. Louis University, St. Louis, Mo. R. R. Heinrich, J. B. Macelwane.

REICKERT, FREDERICK A., Associate Professor of Civil Engineering, University of Illinois, Urbana, Ill. J. C. Dietz, T. C. Shedd.

RICE, WARREN, Instructor in Mechanical Engineering, A. & M. College of Texas, College Station, Texas. R. M. Wingren, R. V. Jarvi.

RICHARDS, CEDRIC W., Instructor in Civil Engineering, Stanford University, Stanford, Calif. E. L. Grant, H. A. Williams.

RUSSELL, ARTHUR L., Head of Electrical Dept., Franklin Technical Institute, Boston, Mass. R. G. Adams, P. H. Humphries.

SHAUGHNESSY, THOMAS E., Deputy for Education, The Ordnance School, Aberdeen, P. G., Md. D. C. Jackson, Jr., F. E. Roediger.

SPENCE, DAVID W., Instructor in Electrical Engineering, Syracuse University, Syracuse, N. Y. S. Seely, R. A. Galbraith.

STRUM, ROBERT D., Instructor in Electrical Engineering, Rose Polytechnic Institute, Terre Haute, Indiana. C. C. Knipmeyer, R. M. Ross.

170 new members this year

New Hampshire—Versatile Vacationland

Annual Meeting ASSE.

Dartmouth College—June 23-27, 1952.

By JANE A. BENNETT

Assistant, Office of the News Service, Dartmouth College

Crowned by Mt. Washington, highest point in the East, and embellished by cool forests, rolling hills, scenic lakes and rivers, and a tiny patch of seacoast, New Hampshire in the summer is as good a place to live and play in as it is to look at. The topography, the weather and the people have banded together to make the state one of the most versatile recreation areas in the country. The artist and the mountain climber, the fisherman and the tourist will all find what they seek in the Granite State.

Besides the man-made recreational facilities and such natural attractions as lakes and mountains, New Hampshire has an ideal summer vacation climate, pleasantly warm days and cool nights. This variability in temperature is healthful as well as enjoyable.

Parks, maintained in all parts of the state by the Forestry and Recreation Department, offer camp sites, hiking trails, fishing, swimming, and picnicking areas; private organizations such as the Appalachian Mountain Club and the Dartmouth Outing Club help the U. S. Forestry Service in caring for the miles of tramping trails which cross and recross the state; Yankee hostelries invite the traveler at all seasons of the year, and Yankee ingenuity provides him with things to see and do.

The northernmost part of the state is noted for its fish-laden Connecticut Lakes where land-locked salmon, lake trout and brook trout tempt the anglers. The Connecticut, which forms the greater part of New Hampshire's western boundary, has its origin in these northern lakes.

Another favorite fishing spot, not far from Dartmouth College, is Lake Sunapee, famed for its *aureolus* or golden trout which is exclusively a New Hampshire fish. Hundreds of streams and ponds provide brook and rainbow trout, bass, pickerel, and land-locked salmon, and new fishing areas are constantly being created by reclamation and stocking.

Moose Brook State Park, north of the Presidential Range, is well located for the trout fisherman because the Ammonoosuc and Moose Rivers and several of their tributaries run through the area. For the salt-water fisherman New Hampshire offers the waters off New Castle and the Isles of Shoals where bluefin tuna may be speared.

Since Pinkham Notch is the headquarters of the Appalachian Mountain Club, hikers flock to the Granite State. A system of shelters is maintained and the trails are kept in good condition in the White Mountain National Forest and the numerous state parks.

Wellington Park, not far from Hanover, Monadnock Park, in the southern part of the state, and Moose Brook and Mt. Prospect Parks in the White Mountain area are networked with hiking trails, some of which double for skiing

during the winter months. Mt. Sunapee State Park and Belknap Recreation Area near Guilford operate as both summer and winter parks, running chair lifts the year round for sightseeing and skiing and providing good swimming and playing facilities.

New Hampshire's parks are a great credit to the state. All provide attractive picnicking areas and are well maintained. Most parks have camping sections and, wherever possible, bathing places. Rhododendron State Reservation in the southern part of the state is a naturalist's playground in July when the shrub which gives the park its name is in bloom. Weekly square dances and the annual craftsmen's fair are held in the Belknap Recreation Area. Mt. Sunapee Park provides such summer attractions as periodic lobster feasts and clam bakes atop the mountain, Blanket Pops concerts, and the annual Guides Show, a field day for woodsmen.

Many recreational facilities are offered by private concerns. Dartmouth's Mount Moosilauke, near Warren, lures climbers with its pleasant climbing trails and the comfortably rustic Ravine Lodge at the foot. The Maine-to-Georgia Appalachian Trail runs through the reservation. Franconia Notch, Tuckerman Ravine, North Conway and other New Hampshire spots that are by-words to the Eastern skiing fraternity have their summer appeal as well. The Mt. Cranmore skimobile at North Conway and the aerial passenger tramway at Cannon Mountain are busy all year round taking visitors to mountain peaks from which spectacular views are to be had. The tramway, opened in 1938, is the only one of its kind in North America. Its glass-enclosed cars, hanging from heavy cables, carry 27 passengers at a time from the valley station to an elevation of over 4000 feet.

The Presidential Range from Pinkham Notch

New Hampshire's recreational facilities are not all for the outdoorsman; the vacationist who likes to relax or take sightseeing tours is welcomed by the state's hostelries which range in style from the sumptuous Mount Washington Hotel at Bretton Woods to the simplicity of the cabin courts. Although many vacation resorts provide recreational facilities, a series of day trips from almost any place in the state will yield a variety of sights and activities.

Visitors to the White Mountain National Park must crane their necks to gaze up at the "Old Man of the Mountains" high on Profile Mountain. This is only part of a 6000-acre wonderland known as Franconia Notch. In the park cutting precipitously into the rock at the foot of Mt. Liberty is the Flume, a geologic chasm almost 700 feet long. A drive through Franconia Notch is an easy trip from the vicinity of Hanover.

Mt. Washington with its cog railway is an attraction for all New Hampshire's visitors. The highest peak east of the Rockies and north of the Carolinas has a weather all its own; passengers on the famous railway riding up in the sunlight may arrive at the summit in a cloud bank or may be treated to a view of several states. There are a hotel, an Air Force icing research station, and a weather observatory on the mountain top.

The Connecticut River Valley Near Dartmouth College, Hanover, N. H.

The cog railway, reputedly one of the shortest, safest, and most expensive railroads to operate in the world, was invented by Sylvester Marsh and the first ascent was made in 1869. Marsh allowed Swiss engineers to copy his railway for the Alps. Both the automobile road and the railway are open until the middle of October.

At the Lost River Reservation, west of Franconia Notch, there is a tour through the scenic gorge filled with phenomena of nature, and Kinsman and Crawford Notches are targets for many visitors' cameras. As an aid to travelers the state of New Hampshire has carefully labeled its views by means of roadside signs.

South of the White Mountains is one of New Hampshire's biggest and best-known playgrounds, Lake Winnipesaukee. The lake, a few hours drive from Dartmouth College, is over sixty miles around with an indented, tree-lined shore. Life on or near the lake varies from the seclusion of an island camp to the liveliness of a few of the towns which go in for the typical tourist attractions—boat trips, casinos, and beauty contests. Winnipesaukee is surrounded by many smaller, and equally lovely lakes, all thickly settled with summer hotels and children's camps.

South of the lake region, on New Hampshire's diminutive seacoast lies Portsmouth, which is a bit of the 18th century held over to the present day. Submarine-building in the Portsmouth Navy Yard, actually across the river in Kittery, Maine, is the main industry in a city where once considerable wealth was brought by sea trade and the ship-building and whaling industries. Many old mansions are located near the harbor. Most of these "castles" of the princes of commerce, set close to the narrow brick sidewalks, are now maintained as museums by historical societies. The city

has been immortalized in the writings of Thomas Bailey Aldrich.

Just out of Portsmouth Harbor lie the Isles of Shoals, only one of which is inhabited. These islands boast of a wealth of tales about pirates and buried treasure, early explorers, and prohibition rum-runners. On Star Island are a hotel and cottages maintained for the Congregational and Unitarian-Universalist summer religious conferences. South of Portsmouth stretch the state's beaches which attract hoards of visitors. There are fashionable resorts at Rye and Jenness and a large state park at Hampton Beach, just north of the Massachusetts line. This is the area for the vacationist who likes to sun-bathe, swim, and eat lobster. Though small, the seacoast area attracts its share of the vacation throng.

Back from the coast itself are such picturesque towns as Exeter, home of Phillips Exeter Academy, and Durham, site of New Hampshire's state university. These towns have the shady streets and dignified homes that typify New England, and have, in addition, the sightly campuses.

Another campus that does credit to New Hampshire is that of Dartmouth College, crowning the banks of the Connecticut River in the west-central part of the state. The college is as near to the many picnicking and amusement spots of Vermont as to those of the Grantite State. Daily many visitors come to Hanover and take advantage of the guided tours around the campus, featuring Dartmouth's Baker Library and the fine athletic facilities of the college. Both Dartmouth and the University of New Hampshire open their campuses during the summer to conference groups and special summer schools.

Many houses of historic significance are open as museums, some during the summer months only. At Center Sandwich is a Museum of Original U. S. Patent Models and a clock museum is located at Georges Mills. There are art exhibits and craft shows throughout the summer months in various parts of the state. Annually the League of New Hampshire Arts and Crafts sponsors a fair in Guilford; it also maintains retail stores for league members' wares. Summer art schools sponsor exhibitions, and galleries such as the Currier Gallery in Manchester and the St. Gaudens Memorial in Cornish have a varying program of displays.

Summer theaters flourish, and numerous water carnivals and boat races are held on the lakes. There is even a summer ski jumping event held on crushed ice in the Belknap Recreation Area. Tennis and golf tournaments, horse shows and dog shows are popular features during the summer months.

The State Planning and Development Commission, at Concord, puts out a Recreational Calendar each year which lists the dates of athletic events, animal shows, summer conferences, fairs—both the street and county varieties, and any special events of the season. Programs for the summer theaters are listed and the opening and closing dates for state-run parks.

There are summer schools and conferences, varying in length from a week to the entire summer. All sorts of people, from credit executives to camp nature counselors, from music educators to motor vehicle fleet supervisors, come together to study or confer. Writers' conferences and folk dance camps are now regular parts of a New Hampshire summer. In Peterborough there is the well-known McDowell Colony, a retreat for artists, writers, and composers who want to work without disturbances and distractions. Founded by Mrs. Edward McDowell after her husband's death, the colony provides for other artists the atmosphere the composer found so beneficial to his work.

New Hampshire is everybody's playground. The State Planning and Development Commission in Concord has issued statements showing the marked increase in the vacation industry from year to year. The Commission, always ready to provide information to any would-be vacationists, is constantly trying to make the versatile state still more attractive to natives and visitors alike.

Education for Action*

By W. L. EVERITT

Dean, College of Engineering, University of Illinois

A good educational program requires sound planning, both in the design of the curriculum and in the presentation of individual courses by the instructor. Sound planning requires a clear definition of objectives. To be effective in operation the objectives of an educational plan must be understood and concurred in by both the teacher and the student. The objectives should be limited in number but be sufficiently clear that they can be used to make decisions on methods and procedures. From an engineering viewpoint, the objectives might be considered as dimensional guides to bound the problems which are met from day to day.

Objectives which are now universally accepted in university teaching are:

1. Teach to Think.
2. Teach Fundamentals.

I propose a third objective which I believe can help us to reach sound decisions in the planning of curricula and in the conduct of individual courses. It is:

3. Teach to Achieve Action.

A particular curriculum must, of course, be planned within the framework of the profession. Within this ever-expanding framework these three objectives may bound particular problems as indicated graphically by Fig. 1.

I submit these premises:

1. The basic aim of the professional man is to achieve sound action.
2. The basic job of the teacher of professional men is to prepare his students to do this.

We must then answer the question: Does our program prepare him for the steps necessary to secure sound action?

Steps to Action

What are the steps necessary to secure action and what is their sequence? My conception of them is indicated by the chart shown in Fig. 2. The next question is: What impact does the analysis of this chart have upon an engineering educational program?

We immediately recognize that most problems develop from the experience of the past, with roots in our history. Some roots are shallow, others deep. It would appear that history—particularly that of our profession, of the Industrial Revolution, and of our social and political structure—is an essential part of the education of men who are to solve the problems of the present and the future.

We recognize next that one of the most important skills necessary for the solution of problems is the ability to formulate and divide them so that they can be tackled with the tools available. Problems are usually formulated almost entirely by the instructor. The student gets very little experience in this essential activity. Adequate planning by the instructor can correct this deficiency.

* Presented at the Educational Methods Conference, ASEE Annual Meeting, June 26, 1951.

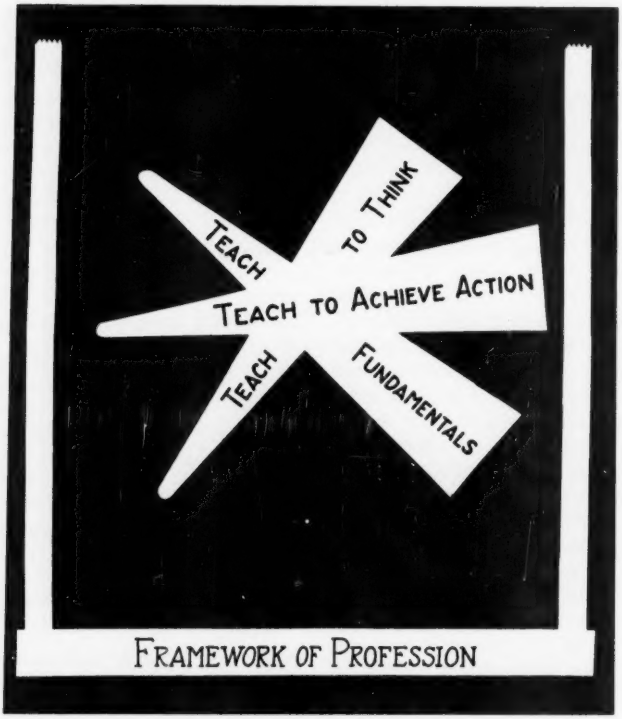

FIG. 1. Dimensional guides in the development of engineering curricula and courses.

Laboratory courses, particularly, can be so developed that only the broad purposes of the experiments may be outlined and the detailed formulation of the problems may be left to the student.

After formulating and dividing the problem, the next step is to collect information. In both laboratory and classroom instruction, we far too commonly provide the student with just the right amount of data, no more and no less. If he does not use some of the data, he feels he is in the same situation as if he had reassembled a machine and found a few bolts and gears left over. He uses this as a clue that he has made a mistake. But in an actual problem an engineer would have the whole world of information at his disposal. He inevitably collects some that he needs and some that is of little or no importance. The sorting of this into that which is relevant and that which is immaterial is an important part of his professional procedure. He also has to know how to find information which is available, what he must secure by his own experiment and observations, and how to get material from discussions with others. The art of collecting information is not intuitive but must be learned. Our educational program requires a progressive weaning process so that by the time a student graduates he is ready to proceed without too much spoon feeding or guidance.

We next observe that information must be subjected to two types of analysis. One is quantitative or mathematical; the other involves many other considerations which cannot be reduced to numbers.

Our present engineering education stresses almost entirely analyses associated with mathematical operations. Nevertheless, we know that many engineering decisions must be made on the basis of human reactions, customer appeal, labor relations, company policy, etc. It is true that this area is more difficult to teach. Skill in this type of evaluation also depends upon experience and maturity which may not be susceptible to too much acceleration. But in setting up our problems we should emphasize that, in the practice of the profession, this type of evaluation is important, and that, frequently, the skill with which it is done determines the speed and distance which the individual may move in his career. It also indicates the practical importance of the humanistic-social stem now being developed in engineering curricula and helps to convince the student that he must pay serious attention to these areas.

Analysis, whether mathematical or nonquantitative, is wasted unless it is translated into conclusions. At this point the engineer may find that something is missing; he may not have collected enough information or the right information. He may not have formulated the problem properly. This discovery indicates that he may have to go back some-

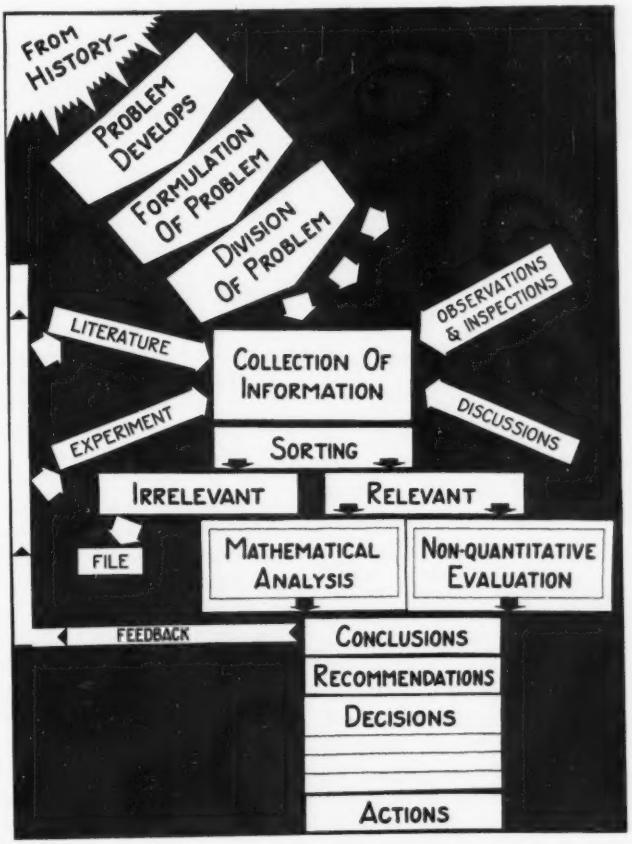

FIG. 2. Steps in securing sound action.

where along the line and change his statement of the problem or get additional information.

On the chart (Fig. 2) I have called this process "feedback" by analogy to a linkage now recognized as of great importance in many physical systems. Properly done, feedback will provide a stabilizing influence on the operation or operating system. Improperly performed, feedback may result in instability. An unstable situation in problem solving is indicated by the individual who can never reach a conclusion because he is never satisfied that he has enough data to be "sure." Engineers seem particularly prone to this fault, and students can be helped by experience with problems which do not have a unique answer, or where the information may be inadequate. Remember, engineers frequently must make conclusions on insufficient evidence or incomplete data.

Specific Recommendations

In practice, conclusions must be followed by specific recommendations for action by others. These recommendations must be followed by a whole hierarchy of decisions before they can be translated into action. The securing of decisions is usually accomplished by oral persuasion and written reports. Engineering curricula on every campus are noted (or should I say notorious?) for the number of reports which the students are required to write. But have we been using these reports for real training in persuasion, their most important function in professional practice? It can never be accomplished by stereotyped forms. We have, in general, created a paradox: we have required so many reports that our students have not learned how to write a real report. Would it not be better to require fewer reports but have them addressed to different hypothetical readers? One might be a simple memorandum to refresh the writer at a later date, i.e., addressed to himself. Another might be a memorandum to establish priority in a patent case. Another could be addressed to his technical superior. Still another might be intended to secure agreement with his recommendations by both an engineering supervisor and a non-technical officer of his company. Finally, he might prepare a report of a technical development for presentation to a service club. Varying the hypothetical reader and the aim to be accomplished would give him experience in reducing his conclusions or observations to writing that is focused and effective.

Ultimate improvement in engineering education must depend not merely on changing the names of courses within the curricula, but also on the method of teaching courses now recognized as essential in their technical content. This is particularly true if we are to develop real facility in problem formulation, collection of information, broad analysis, and presentation.

Engineering practice involves processes of integration, the use of many sources and disciplines to supply a service or machine useful to man. Even when we are working or teaching in a limited area, we should keep the problems of synthesis or integration illustrated by the chart of Fig. 2 well in mind. It would also appear that we should give more consideration to teaching by the "case method" which has proven so effective in other professional curricula, notably law.

Fortunately, since problem-solving is a necessity in every form of human activity, the proposed objective of "Teach to Achieve Action" gives guidance in preparing the student for educated citizenship as well as for a professional career. Hence, this presentation should not be interpreted as a plea to educate only in practical fields, except as all education which is related to living may be considered practical.

I realize that not all the items discussed here can be introduced into every

course. They will be more difficult to incorporate in sophomore physics than in senior courses. I also recognize that a program taking these ideas into account may be more difficult for the instructor, particularly in the problems of grading. But if our objectives are clear to our students and are acted upon by our faculty, marked progress can be made even within the confines of the existing shortage of time in our engineering curricula.

In summary, the objective "Teach to Achieve Action" indicates that the following items are important in both our curricula and course planning:

1. Knowledge and appreciation of history.
2. Formulation of problems.
3. Collection of information.
4. Distinguishing the relevant from the irrelevant.
5. Non-quantitative evaluation, particularly involving human reactions, as a companion of numerical analysis.
6. Translation of analysis into conclusions which are then reduced to specific recommendations.
7. Oral and written presentations in a form designed to accomplish a clearly perceived, practical purpose

James H. McGraw Award in Technical Institute Education

The purpose of this award is to recognize and encourage outstanding contributions to technical institute education. Candidates for it may be teachers, authors, or administrators who are, or have been, affiliated with an institution which offers or sponsors training of the technical institute type.

This is an annual award of the sum of $500, and it is made at the annual dinner of the Technical Institute Division of the American Society of Engineering Education each June. It is made upon the recommendation of the James H. McGraw Award Committee, members of which are appointed annually by the President of the American Society of Engineering Education. Nominations for the award should be sent to the Chairman of the Committee, Professor H. P. Adams, Oklahoma A. & M. College, Stillwater, Oklahoma, by March 15, 1952. The award is made possible by the McGraw-Hill Book Company in memory of James H. McGraw.

Cooperative Graduate Study*

By N. W. DOUGHERTY

Dean of Engineering, University of Tennessee

At the Fontana meeting last summer we made a brief report regarding possible cooperation on a graduate level with such agencies as the Tennessee Valley Authority. After the meeting at Fontana we have made some further exploration of this problem.

A few of those present at Fontana attended a meeting of the Board of Control for Southern Regional Education at Daytona Beach, Florida in early September. One of the topics for discussion was possible cooperative graduate study with industry. The writer served on one of the work committees for the three days of the conference. A statement of principles which should be used in developing such a program follows:

1. That the primary conception of the utilization of agencies in graduate education by institutions is founded on the realization of mutual benefit, and that the institution-agency relationship is consistent with the educational purposes of the institutions and the respective purposes of the agencies.
2. That the responsibility for awarding academic degrees shall reside in the institution. In this connection the institution will approve standards of instruction and programs of study and research, and will be responsible for the evaluation of student accomplishments, including the research entering a dissertation from the point of view of its acceptability for satisfying institutional requirements.
3. That there should be developed proper standards for acceptance of residence credit for work done in the agency under programs approved by institutions and agencies.
4. That the institution shall approve the eligibility of the agency staff to guide and to assist in the direction of research, including thesis research, and shall recognize the desirability of agency staff participating in the final examinations of students whose research they have guided.
5. That the agency shall have the right of approval of institutional staff and of graduate students for work within the agency.
6. That there shall be prior mutual agreement between the institution and the agency on policies governing the publication of research findings.
7. That there shall be ways provided for the exchange of information between institutions and agencies relative to research in progress and other educational opportunities in which both may be concerned.
8. That opportunity for work in agencies shall be sought for full-time teachers as a means of broadening their professional experience and increasing their teaching proficiency. Conversely, that opportunity for academic work in institutions shall be sought for agency staff as a means of broadening their professional experience and increasing their technical proficiency.

* Presented at a meeting of the Southeastern Section of ASEE, Biloxi, Mississippi, March 24, 1951.

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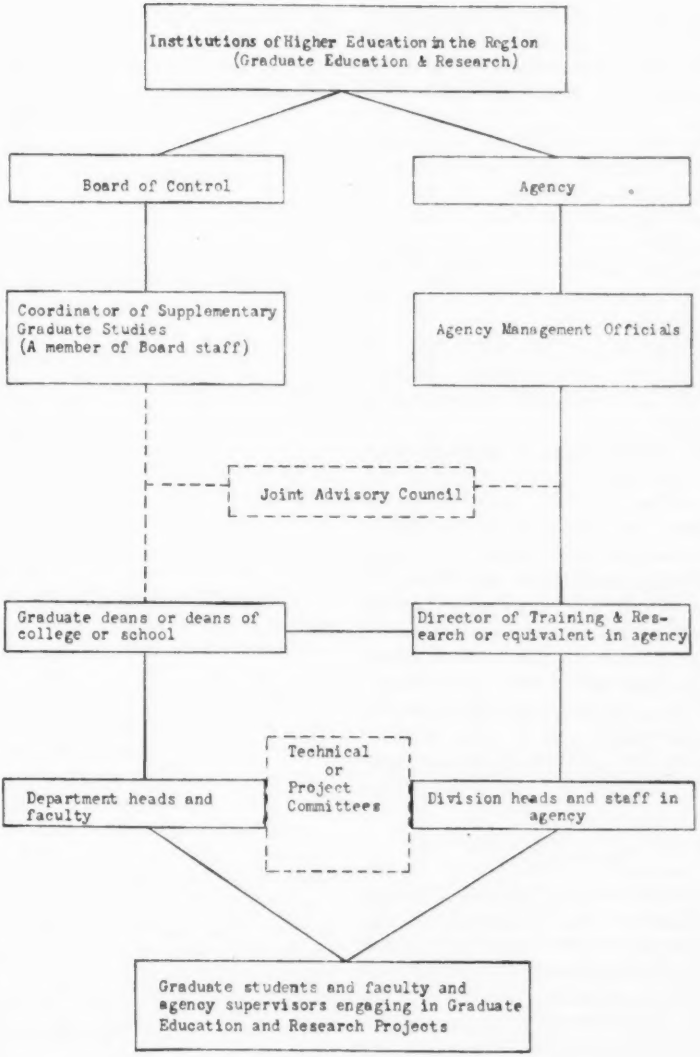
Institutions of Higher Education in the Region
(Graduate Education & Research)
Board of Control
Agency
Coordinator of Supplementary Graduate Studies
(A member of Board staff)
Agency Management Officials
Joint Advisory Council
Graduate deans or deans of college or school
Director of Training & Research or equivalent in agency
Technical or Project Committees
Department heads and faculty
Division heads and staff in agency
Graduate students and faculty and agency supervisors engaging in Graduate Education and Research Projects

The Board of Control will undertake to bring an agency in contact with the member institutions; after the contact has been made, the program will be developed by the institutions themselves in cooperation with the agency; and there will be no effort on the part of the Board of Control to dictate policies regarding either the graduate work or the possible thesis work in industry. Representatives of the Tennessee Valley Authority were present at the meetings and they made

excellent contributions to the deliberations. A representative was also present from the Air University at Montgomery, Alabama. Attached hereto is a chart showing the organization of graduate work under the plan proposed. (See page 3.)

After returning to Knoxville we made some explorations with industries such as the Aluminum Company of America and the Tennessee Eastman Corporation at Kingsport. We had rather favorable replies from most of the industries contacted. The problem apparent in each of the discussions was the type of work which could be done and which would be acceptable for thesis credit. This, it seems to me, is the heart of the possible cooperation.

After reviewing the discussion at the ASEE national meeting last year, and after discussions with industry, we, at Tennessee, have come to the conclusion that more than one institution should try a pilot program in this field, and undertake to discover the difficulties which may be reported back to the colleges at a subsequent meeting. With this in mind, we have developed a program and will undertake it during the coming year, provided, of course, we can get graduate students. We have made some announcement to industry, and will make further announcement as time goes on.

Program Outline

Our present concept is that we will accept competent graduate students at the beginning of the Fall quarter, and that these students will continue in residence at the University for two quarters, or until they have acquired thirty quarter hours of graduate credit. They will then be placed in industry for six months. A faculty member of the institution will confer with a scientist in the industry on the possible thesis problem. The amount of credit that will be given for the thesis will be determined in advance, and the student, after he has begun his work in industry, will begin reports back to the faculty member in the University. If the problem is such that he can complete his writing during the six months stay in industry, all will be very well. If he has not completed his thesis he may return to the University and stay a sufficient amount of time to complete the study; then he will take his oral examination.

Since our requirement is the equivalent of forty-five graduate hours, this means that the thesis may be given as much as fifteen hours credit. Less than fifteen hours, of course, will require that the student return to the University and take more course work.

It has been difficult to set up a program which will have an appeal to the student. Our graduate council has been willing to give one-quarter residence credit for the six months of industrial residence, provided the work done in industry is of a caliber to warrant thesis credit. If no credit is given for the thesis, then of course there will be no residence credit going with it. This is the loose end of the program.

We are convinced that there are problems in industry and methods of cooperation which will allow the student to satisfactorily complete a thesis while he is on the job. Our experience, for example, at the Norris laboratory indicates that a problem may be selected which is of interest to the Tennessee Valley Authority, and certainly of sufficient importance to allow the student to work for thesis credit. I am sure that there are certain problems in design, especially in the fields of civil and mechanical engineering which may be done by a student and reported to his professor for graduate credit.

Industry is very anxious to find employees from any source. This may be a part of the reason for their optimism in stating that they are willing to start the cooperation. It is our hope that we can develop the work in industry to such a

point that it will contribute to the graduate education of the student. If this cannot be done, then a graduate program in industry will be of very doubtful value, except as a possible source of earnings to complete the rest of the program back at the university in residence.

We invite comment on, and criticism of, the plan. We hope that within a year or two of trial we can report back that the scheme is workable. We will be very glad to exchange information and experience with any other college of engineering which will undertake such a program.

College Notes

The governing board of the **Colorado Agricultural and Mechanical College** at Fort Collins has approved the offering of a Ph.D. in Irrigation Engineering. This is the first doctor's degree to be offered at the College and is in a field for which it has achieved a notable record since 1887. The degree will be administered in the department of Civil Engineering, which has been offering advanced work in Irrigation Engineering for a number of years. The work will be given in conjunction with programs of the Irrigation Institute. These are broad and intended to cover all aspects of the field of irrigation agriculture. In engineering it can include theoretical or applied fluid mechanics, design, soils and water, operation and management, or project planning.

Dr. Paul E. Klopsteg, Professor of Applied Science and Director of Research of Northwestern University, has been appointed Assistant Director of the **National Science Foundation** for the Division of Physical, Mathematical and Engineering Sciences. This Division is the largest in scope of the Foundation's four science divisions. With the aid of expert consultants representing the various scientific areas included in his division, Dr. Klopsteg plans to begin work immediately on a program of research support in these areas.

Carnegie Institute of Technology has received a $300,000 grant from the A. W. Mellon Educational Charitable Trust to permanently establish A. W. Mellon scholarships. The grant is in the form of an endowment, income from which will be used by the school to help approximately 35 deserving students each year. Established in 1938, the scholarships were maintained until now by yearly grants from the Mellon Trust.

An $80,000 scholarship program, designed to help alleviate the critical shortage of industrial engineers, has been initiated by the Reliance Electric & Engineering Company. The program provides for the admittance of eight qualified high school graduates annually to the School of Engineering of **Fenn College.**

Extension Instruction in Engineering

By C. W. BEESE

Dean, Technical Extension Division, Purdue University

A program of instruction in "mechanics" or comparable technical courses and which is within the broad field of "adult education" is sufficiently important to warrant analysis of the influencing factors which determine the feasibility of such a program. There are some fundamental considerations which more or less determine the characteristics of a program of this kind. These considerations may be used to evaluate any adult education situation and arrive at a recommendation based upon the relative importance of the factors involved in a situation under study.

Dr. Holt's discussion describes a solution to an adult education need arrived at in a situation where the schools and the industries served are located in close proximity. The programs which he outlined have proved by experience that they serve effectively the needs of the students and the industries and safeguard, at the same time, the academic respectibility of the universities involved.

Fundamentally any adult education must be satisfactory to the student, to his employer, and to the sponsoring educational unit. The program must be satisfactory as to quality, appropriateness and cost. It arises from a need by qualified students expressed in a desire for culture or for vocational proficiency. The need may be translated into an operable program providing qualified teachers are available, physical facilities are at hand, and the cost of the program is such that economically it is possible through fees or subsidy.

This discussion will review the circumstances which determine whether engineering subjects can be taught within an adult education program at an acceptable cost level and with academic respectibility. Important factors are the numbers and qualifications of prospective students, availability of an acceptable teaching staff, the demand for instruction as it is translated into subject matter areas, relative geographic locations of the institution and its branches and the students at work and at home, fiscal policies as to fees and subsidy for instruction and procedures of operation, both academic and financial.

Some limitations which affect adult education in the fields of engineering are not of importance with regard to general adult education activities. In the subject matter areas of engineering, whether in mechanics or some other subject, it is ordinarily true that satisfiable needs exist mainly in an industrial concentration. Such a concentration of industry is more important when it uses much engineering and many engineers. It is in this situation that needs for further study arise from the desire on the part of engineering personnel for job advancement, because the industry must offer educational opportunities as an inducement during recruiting or because industry requires technical training in order to conduct its business.

An engineer interested in further study is fortunate if his residence and

* Presented before the Engineering Mechanics Division at the 59th Annual Meeting of the ASEE, East Lansing, Michigan, June 29, 1951.

his job are located close to an institution of engineering education. It is possible to pursue in evening classes many of the subjects given to campus students on a schedule which does not interfere with full time employment. Campus facilities in laboratories and campus teaching personnel are available for evening instruction. Where part-time or visiting lecturer instruction is used, the supervision from the subject matter department is relatively simple.

The student employed by an industry in a locality where there is no technical educational institution is up against quite a different proposition. He, or the educational facility, must travel. If he is one of a small number, the possibilities of his getting instruction at home are none too good. If he is one of a large group, it is economically possible to bring the instruction to him. The type of program, the subjects offered, the level of instruction, the fees charged are all affected by a need for instruction at a locality other than where an engineering institution is located.

Responsibility of Subject Matter Department

The subject matter department must be thoroughly convinced of the worthwhileness of adult education. It must recognize that the activity is just as respectable and must as honestly carry the stamp of approval as if a class were on the campus. The assumption of responsibility by the subject matter department for quality of instruction means a very close contact with the teacher, a check on the qualifications of the students, and a thorough understanding of the problems involved in the operation of the class. A campus teacher may never receive a critical visit from his department head. On the other hand, an off-campus class in a catalog course or an adult education class which is outside of the regular catalog listing needs and should get close supervision of a helpful type.

The responsibilty for an adult education class in engineering on the campus or at some distance from it involves many of the sub-divisions of the sponsoring institution but it is generally accepted that the subject matter department assumes the major responsibility with regard to instruction. This responsibility involves the educational aspects of the class such as the quality and level of instruction, course content, use of text and supplementary reading, the selection and supervision of teachers, and the quality of instruction with respect to its suitability to meet the recognized need.

When the educational institution gives no credit for the class work and the students are satisfied that they are getting what they want at a cost which they are willing to pay, supervision is less critical. However, if credit, either undergraduate or graduate, is involved then the university must not only satisfy its own requirements but put its label only on educational achievements which may be certified to another institution with a guarantee of quality.

The selection of a teacher for an adult class may be more critical than for a class of undergraduates on the campus. Undergraduates take courses in a fixed curriculum and credit in courses must be obtained in order to receive a degree. On the other hand, adults take work because they feel they are getting a fair return for their investment in time and money and are quick to complain about or drop out of a class if they are not happy. The teacher is more frequently on the spot than the student. It has been said that on the campus, the teacher flunks the students but in adult classes, the students flunk the teacher.

The choice of a part-time teacher from industry is important too and just as critical. Many persons from industry know subject matter. But in addition they should be able to handle a class with some degree of facility. A teacher, whether he is from the campus or from industry, must be able to point his course

to meet the needs and level of preparation of his students.

A teacher of an adult education class must frequently furnish much more material in the form of teaching aids and supplementary reading than if he were handling a campus class. Adults are strongly motivated, but, on the other hand, do not have the study facilities nor are they in the study habit like undergraduates. The teacher need not necessarily go more slowly but he needs to guide just as carefully.

Adult education as it is usually defined includes a wide variety of offerings. When the program is within the fields of engineering the course offerings are usually those found in a university curriculum. These courses may be for credit or they may be without credit. Primarily this choice depends on the use which the student wishes to make of the training he receives. Work taken "for credit" usually means that the credits received are applicable to some kind of a degree. This may be an undergraduate degree or an advanced degree obtained through graduate level study.

Work of this kind in engineering subjects is more frequently found in organized classes conducted similarly to the way classes would be held on the campus. There is, however, some work given through correspondence and while this may be the smaller amount, it is an important type of instruction.

Credit and Non-Credit Courses

In a group of persons interested in engineering study, there is usually a mixture of those who want credit toward an immediate or a possible degree objective and those who are interested in study for the sake of personal development alone. It is not always possible to organize these groups separately. In other respects they may be quite homogenous and the total group if split in two is not financially economical. It is not as important to scrutinize the qualifications of persons who are not interested in credit. If they have a background such that they may profit by as much or as little as they wish to do and are willing to carry the cost financially, there is no good reason why they should be denied the privilege of going to class. On the other hand, a mixture of both groups in a class may cause difficulty. Persons less qualified and who join classes as visitors or non credit students may monopolize an instructor's time if it is permitted. If they are less prepared, they make it difficult for the teacher to hold instruction to a "credit" level. A visitor in a class ordinarily has no rights with regard to discussion or individual attention, except what he may contribute to the general fund of information. The teacher has to recognize his responsibility to those who are obtaining work of a pre-determined level of quality and quantity. He has much less responsibility for recognizing the visitor except as a' listener. A sprinkling of non-credit or visitor students may be beneficial but where separate classes can be developed, it is preferable.

Special courses can be organized for students of a specific industry. Problems may involve operating practices within a plant and the class itself may be held within the plant. Closed classes have certain advantages. Where the teacher is familiar with the situation within the industry, he may make the class much more worthwhile than if it is a general one. Locating the class within the plant saves time of the students and if the instructor may come to the class an overall saving can result.

Public institutions are not in a position to offer closed classes exclusively. Any industry and any individual have equal privileges. A closed class, therefore, offered for the employees of a company must, in most cases, be duplicated by an equal opportunity for other persons who wish the same opportunity.

Most universities have rules which require that a certain proportion of the work toward a degree must be taken

"in residence." The proportion of residence instruction varies from one institution to another. The primary consideration is that a student shall be connected with the institution long enough to get the feeling obtained through contact in and out of class with campus teaching personnel. It is possible to make arrangements so that the complete program may be taken away from the "campus" if work is done in connection with established facilities for instruction.

Student residence is an important consideration for adult education classes. Persons most likely to benefit by further study have jobs and are barred from attendance at a distant class because of job limitations and travel time. Few people can take a semester or a year away from the job to do graduate work. A larger number of persons can benefit by stretching a graduate program over a period of years and continuing with the job at the same time. It is felt that a lessening of the so called residence requirements is justified if suitable safeguards are taken at the same time to insure that the students' qualifications and the quality of instruction are satisfactory.

Promotional Techniques

Adult education, in spite of a general acceptance of its value, must be sold to prospective participants. Evening classes must be made attractive enough to compete successfully with a host of off-the-job activities. Schools try a combination of all the good promotional techniques that they can afford.

Announcements by mail, by poster, by word of mouth, and by suggestion through employers are all important. Such announcements must go to qualified persons in a way which will persuade them to make a major assignment of what would otherwise be recreational time to an activity which, while it may be stimulating, is confining to an annoying degree.

The teacher, his personality and the job he does have a lot to do with the enrollment of repeat courses. This is an element of major importance affecting the value of the instructor to his employing institution.

Registration procedures in cases where credit is involved can follow closely the procedures on the campus. Registration involves recording the information concerning the student himself, the courses he is taking, and the collection of fees. Handling money away from the bursar's office on the campus may involve taking care of money in an out-of-the-way location and at times of day which do not coincide with banking hours. All of these problems are of a business nature, ordinarily do not concern the teacher on the campus at all, and should not be thought of with respect to the total responsibility of the subject matter departments.

Adult education classes are held in a variety of locations. School houses, industries, or almost any suitable space may be used where it can be rented or obtained on a loan basis.

One of the arrangements which involves not only the business of providing facilities but the responsibility of the academic units of the University is the provision of satisfactory library facilities. These may be furnished in a number of ways but are important enough so that some provision should be made for them.

Financial Arrangements

It is generally recognized that adult education activities must support themselves financially though to a varying degree. Few institutions can afford to subsidize such a program beyond furnishing some overhead items. Fees ordinarily carry the direct cost of the teacher and other items directly chargeable to the class, and must carry a contribution toward general overhead as well. The amount of money involved depends, to some extent, upon the type of teacher used in the class, travel cost and some lesser items.

When a campus teacher travels from his home base for a distance which in-

volves a considerable expenditure of his time, the demands of an adult education assignment may be out of proportion to those of a comparable class within his normal campus environment. From one viewpoint, it is only fair that the off campus class carry that proportion of the instructor's salary in ratio to the amount of his total time consumed by the class. This may be a prohibitive charge and can be met only if fees are abnormally high or if classes are larger than good teaching practices ordinarily recommend. Charges for travel may be a sizeable item of cost.

The part-time teacher who has no travel involved, and who may be expected to charge against a class an amount comparable to his effort tempered somewhat by his interest in doing the job, can be handled much more cheaply than a campus teacher. At the same time, this person may require much more supervision than the campus man. Arrangements as to pay for the teacher and the collection of the fees to meet this cost come within the business aspects of the adult education program.

As far as the university is concerned it makes little difference whether the student pays the fee as an individual or whether his employer subsidizes part or all of it. Perhaps the accounting is a little more complicated if the arrangement is flexible but this affects only procedure. For the moment, at least, a more serious complication is where the cost of instruction is borne wholly, or in part, by the Veterans Administration through the subsidies of their program. The university becomes involved in the collection of amounts due for books as well as instruction and must maintain the type of record which bears government scrutiny.

Where off-campus instruction must carry its own weight financially, there is a temptation to develop classes of abnormal size because it is much more economical to teach large groups. Teacher costs for accepted travel and salary are no more for a large class than for a small one. It is accepted that some subjects may be taught in large units. This is not so true in connection with engineering or other technical topics. The size of the class as it actually develops is a compromise between the class large enough to carry the cost of instruction at a reasonable charge per student and the class small enough so that the quality of instruction is satisfactory. It is difficult to set arbitrary figures but, on the other hand, if reasonable consideration is given to the two opposing factors, the resulting answer is not too far wrong.

Where work is taken for credit, the record of accomplishments is logically a part of the registrar's responsibility as if the student were an undergraduate on the campus. Admission requirements especially for graduate students can satisfactorily follow the same procedure as for full time students on the campus. Requirements for degrees and the degrees granted need bear no unusual designation since no actual difference exists in the kind of study program completed.

Low income and high teacher costs for small classes make it difficult for the lone student in a small population area to get the advantages of further study. For him home study methods offer some advantages. There are many subjects where instruction is difficult. On the other hand, this type of instruction is much more valuable than is generally recognized.

Developing a correspondence course means a sizeable investment which must be returned through enrollment fees within a reasonable length of time.

Summary

In summarizing, it may be pointed out that an adult education program can include many offerings in engineering and associated subjects. Such offerings may be at undergraduate and graduate levels, either with or without credit toward a degree. In some situations, such instruction presents little difficulty; in

others it becomes much more complicated and may require some compromises with campus procedures. However, if there are qualified students in sufficient numbers to pay costs, an acceptable teacher available, and proper supervision by campus subject matter departments and business offices, a substantial amount of adult education in engineering is entirely practical. A plan flexible enough to adjust to varying situations can be operated with complete academic respectability and perform a tremendous service to persons who require additional education to advance in the technical environment in which they are employed.

In the News

The $3,500,000 appropriation for the National Science Foundation in the Supplementary Appropriation Act of 1952, will enable the Foundation to start immediately on its two major operating programs: support of basic research in the sciences and training of scientific manpower. Up until now the Foundation has been concerned primarily with planning and with the problems of organization and staffing prior to beginning its operating program.

The reduction in the appropriation from the President's budget request of $14,000,000 for fiscal 1952 has required material scaling down and adjustment of the program originally presented to the Congress. According to Dr. Alan T. Waterman, director of the Foundation, approximately $1,500,000 of the available funds will be allocated for the support of basic research in biology, medicine, mathematics, the physical sciences, and engineering; about $1,350,000 for the training of scientific manpower; and the balance for development of a national policy for the promotion of basic research and education in the sciences, for the wider dissemination of scientific information, and for other services including support of the National Scientific Register, now established in the Office of Education.

Basic scientific research will in most cases be supported by means of research grants. No grants have been made to date, although a considerable number of research proposals have been received from investigators in all parts of the United States. It is expected that many more proposals will be received shortly.

Proposals for research grants will be given preliminary evaluation and review by the Foundation's three research divisions: the Division of Biological Sciences under Dr. John Field, the Division of Mathematical, Physical and Engineering Sciences under Dr. Paul Klopsteg, and the Division of Medical Research under Dr. John Field (acting). Each Division will be assisted in evaluation and review by a Divisional Committee, made up of outstanding scientists in the field, and by expert consultants employed on a part-time basis. Grants will be approved by the Director and the 24-member National Science Board, whose chairman is Dr. James B. Conant, president of Harvard University.

The National Science Foundation Graduate Fellowship program will be directed by the Division of Scientific Personnel and Education under Dr. Harry C. Kelly. Selection of fellows will be made solely on the basis of ability and will be carried on by the National Research Council, which has participated in the selection of fellows for various government and private agencies for many years.

Applications will be considered from students in the natural sciences who have or will have completed their undergraduate work in any accredited college or university. Fellows may attend any accredited non-profit institution offering graduate studies in science which approves their application for admission.

A Study of the Correlation Between Sophomore Achievement Test Scores and College Grades

By J. A. HILL

Director of Student Personnel and Admissions, New York University College of Engineering

The Sophomore Achievement Tests have been developed by the Measurement and Guidance Project in Engineer-Education to provide measuring instruments of value in testing students for promotion and testing applicants for admission to engineering colleges with advanced standing from liberal arts and junior colleges. The first version of the tests was made available in the spring of 1948; revised tests were available in the spring of 1949 and 1950.

This study is based on the results obtained when the tests were given on March 29, and 30, 1948 to students in the College of Engineering, New York University, who at the time were in the latter part of their sophomore year. Although 252 students took the tests, the sample group numbers only 87, for the reason that this study grew out of a larger investigation, which required that the students have taken other psychological tests in addition to the Sophomore Achievement Tests. This factor introduced no selectivity and should have no effect on the results.

The tests were all of the achievement variety and included the following subject areas, with time allowed: English Expression, 55 minutes; Engineering Drawing, 50 minutes; General Chemistry, 90 minutes; Mathematics, 120 minutes, and Physics (Mechanics), 60 minutes, a total of 6 hours, 15 minutes.

In this study the degree of correlation between college grades and test results is measured, in each of the five subject areas, and also on a composite basis. The relation is expressed mathematically in each case by computation of the coefficient of correlation (r), and is also expressed graphically in each case by means of a "scatter diagram."

The coefficients of correlation between college grades in the several subject areas and the test scores in those areas have been computed as follows. (A widely accepted verbal description of the meaning of correlation coefficients states that "substantial" correlation is indicated when "r" is from .50 to .80, and "some" correlation when "r" from .30 to .50.)

Chemistry	$r = .58$
Engineering Drawing	$r = .44$
English	$r = .42$
Mathematics	$r = .48$
Physics	$r = .50$

The coefficient of correlation between the composite test scores and the students' scholastic averages at the end of the sophomore year is:

Overall	$r = .58$

The composite percentile score is the average of the percentile scores on the five subject matter tests.*

The scatter diagrams (Charts 1, 2, 3, 4, 5) portray graphically the relationship

* The obtained correlation coefficients reported here are perhaps slightly lower than they would have been had not certain minor liberties been taken for practical reasons in the use of the product-moment theory.

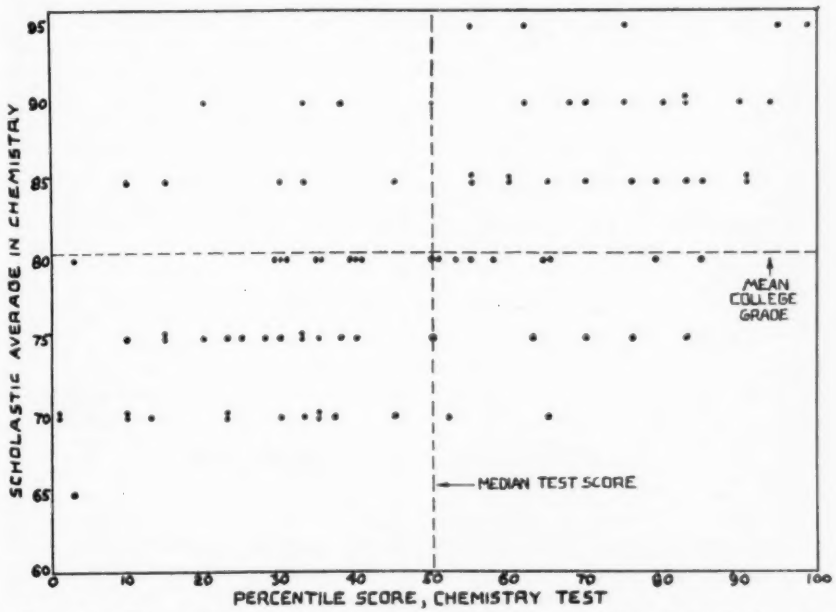

CHART 1. The correlation between scores on the Chemistry section of the Sophomore Achievement Tests and College grades in General Chemistry.

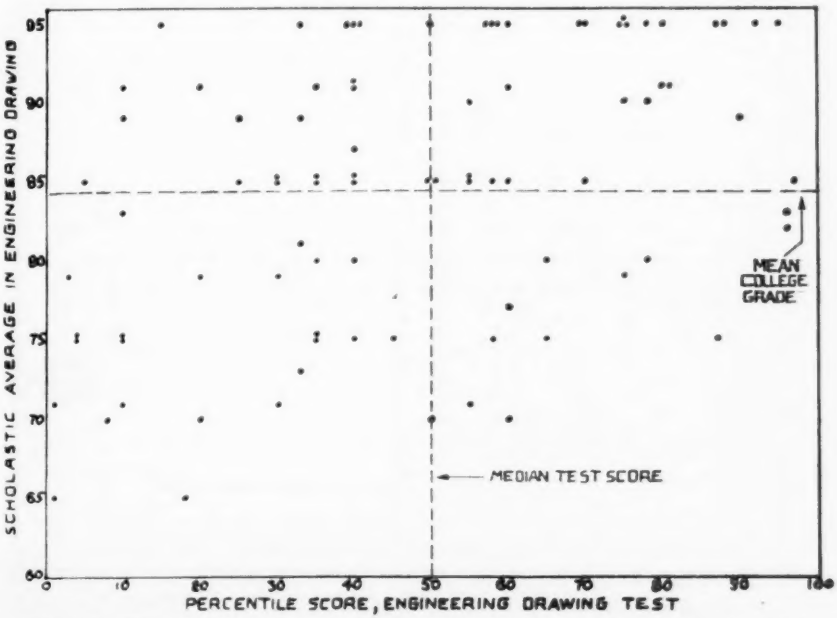

CHART 2. The correlation between scores on the Engineering Drawing section of the Sophomore Achievement Tests and College grades in Engineering Drawing.

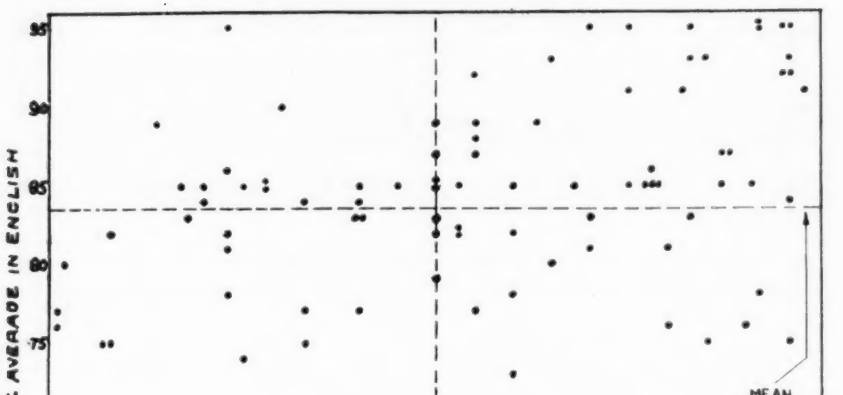

CHART 3. The correlation between scores on the English section of the Sophomore Achievement Tests and College grades in English.

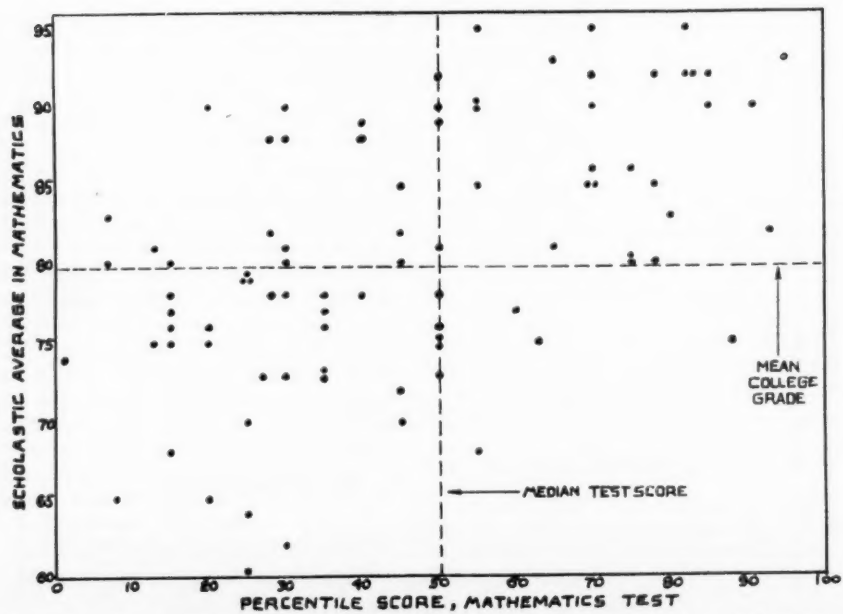

CHART 4. The correlation between scores on the Mathematics section of the Sophomore Achievement Tests and College grades in Mathematics.

between the test scores and college grades. In each case, the student's percentile score on one of the achievement tests is plotted against his average in that subject. The same treatment is used to show the relationship between the composite test score and the student's overall average at the end of his sophomore year (Chart 6).

If there were perfect correlation between the two variables, the dots should form a straight line running from the lower left quadrant to the upper right quadrant, passing through the intersection of the 50th percentile line (x axis) and the group average (y axis). In broad simple terms, dots falling in the lower left quadrant and upper right quadrant are "in phase"; those in the upper left and lower right quadrants are out of place. The dots in the upper left quadrant represent students who did not do as well on the test as might be expected, while the dots in the lower right quadrant represent students who scored higher on the test than would be expected.

The percentile scores are based on norms for 3668 students at 10 colleges who took the tests in the spring of 1948.

It may be observed from the charts dealing with the individual subject areas, (Charts 1 through 5) that the dots are quite widely dispersed, and that in almost all cases there is a comparatively large number of dots in the upper left quadrant and in the lower right quadrant. This dispersion indicates a comparatively low degree of discriminatory power and might be interpreted to mean that the individual tests could not be used with confidence for the purpose of measuring past achievement in, or predicting future performance in, individual subject areas. An exception to this generalization should be made, however, for the Chemistry test. The relatively higher degree of correlation of this test, as com-

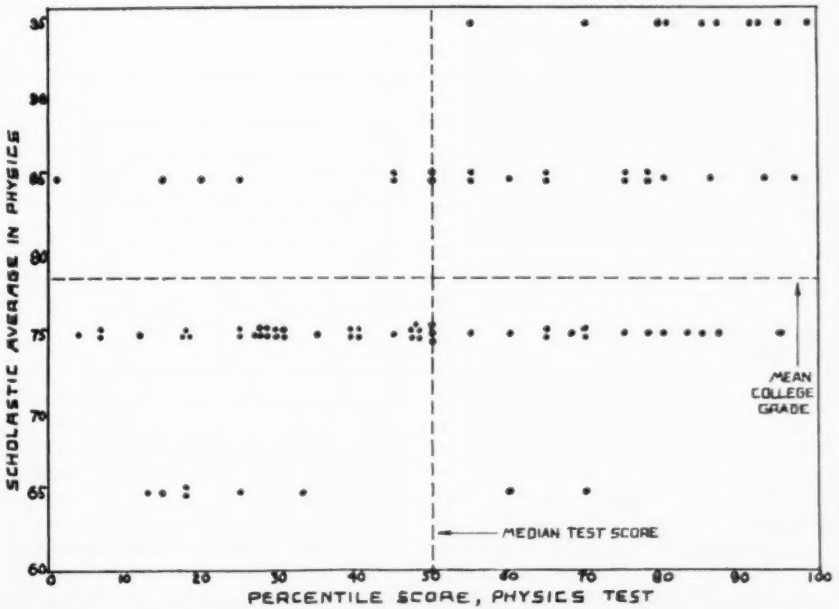

CHART 5. The correlation between scores on the Physics section of the Sophomore Achievement Tests and College grades in Physics (Mechanics).

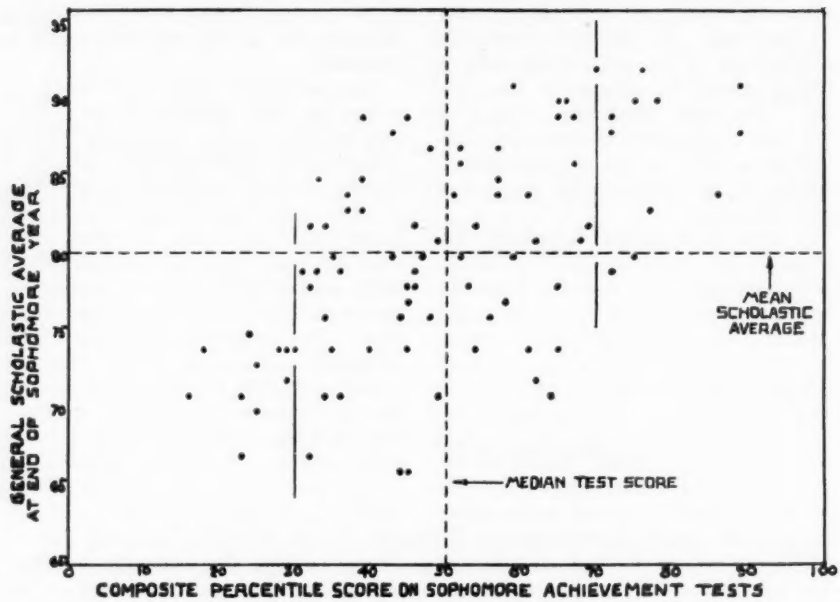
GENERAL SCHOLASTIC AVERAGE AT END OF SOPHOMORE YEAR
MEAN SCHOLASTIC AVERAGE
MEDIAN TEST SCORE
COMPOSITE PERCENTILE SCORE ON SOPHOMORE ACHIEVEMENT TESTS

CHART 6. Showing the correlation between total Sophomore Achievement Test scores and overall scholastic averages at the end of the Sophomore year.

pared with the others, is apparent upon careful examination of the charts. It might also be appropriate to interject here that diagrams of the type used should be interpreted with discretion as a visual illusion factor is sometimes present.

On the other hand, it may be seen that the total test score would be of considerable value in the evaluation of an individual student's attainments. If his total test score is below the 30th percentile, it is quite likely that he has been an unsatisfactory or mediocre student. If his test score is above the 70th percentile, the chances are that he has been a good or excellent student. Note on Chart 6 that of the 12 students attaining composite test scores at or higher than the 70th percentile, all had satisfactory sophomore averages, and only 2 of the 12 ranked below the middle of the group. Conversely, of the 11 students attaining composite test scores at or lower than the 30th percentile, all except one had unsatisfactory averages at the end of the sophomore year. The one exception barely attained satisfactory standing with an average of 75%. Stated another way, a good student is not likely to score below the 30th percentile, and a poor student is not likely to score above the 70th percentile. In the cases of those students whose total test scores fall betwen the 30th and 70th percentiles, the test score will apparently have little meaning. As seen in Chart 6, the college records of students who scored between the 30th and 70th percentiles range from very poor to very good.

The degree of correlation achieved is just about as high as can be expected for a group of tests of this kind, and it is not likely that the discriminatory power of the tests could be raised appreciably. The tests will pick out those students who are almost sure to fail, and those who are excellent bets to perform satisfactorily, but will not draw a line above

which all good students will score, and below which will be found the scores of all the poor students.

The practical value of the Sophomore Achievement Tests would seem to be confined mainly to the selection of applicants for admission with advanced standing. After an engineering college had developed its own norms, the test would facilitate evaluation of transfer applications.

Conclusions

The individual tests showed little discrimatory power. Test scores and college grades in particular subject areas correlated well in the upper ranges, but not too well in the middle and lower ranges.

The high degree of correlation between composite test scores and college averages in the extreme upper and extreme lower ranges seems to indicate that the tests would be useful in the selection of applicants for admission from two-year pre-engineering programs. The tests apparently will pick out those students who are almost certain to succeed, and those who are almost certainly doomed to failure.

September 21, 1950.

In the News

Sixty-seven young Britons, including one woman, have arrived at various universities in the United States under a Marshall Plan program of academic and in-plant training in industrial management and engineering.

The training in the United States, with dollar costs financed by the Economic Cooperation Administration under its technical assistance program, is expected to help increase productivity in British industry by providing a nucleus of industry executives trained in the latest management and engineering techniques. Eighty-six British trainees have previously come to the United States under this program. Some of these have completed their work and have returned home, while others are still here.

Sixteen of this group will study at Syracuse University, the 18 others at the University of Cincinnati. The plant visits will be in the respective areas of the two universities. The program is supervised by the National Management Council for ECA.

The 33 engineers in the other group have qualifications similar to those in the management group in their own field, and they also have agreed to return to their positions in the United Kingdom.

Their program, arranged by the Institute of International Education for ECA, consists of individual studies in the respective fields of the participants. These include electrical, civil and mechanical engineering, mining, textiles, petroleum refining, aeronauties, metallurgy and chemistry.

The academic part of their training will in most cases be for one semester, at 21 U. S. universities, colleges, research foundations and technical institutes. The balance of the training will be practical, at industrial plants or public works agencies. In two cases, trainees are starting the program with the practical training rather than the academic work.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 15, 1952 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of Instructional Division Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

The Graduate Program in Industrial Engineering at the Ohio State University*

I. Graduate Work in Methods and Standards

By HAROLD O. DAVIDSON

Instructor in Industrial Engineering, Ohio State University

While the title of this paper refers to what is administratively defined as the Methods and Standards area, a precise delineation of this area in terms of graduate work is rather difficult. At first, "Methods and Standards" was selected merely as a better name for what is commonly included under the title "Time and Motion Study." As our graduate research progresses, however, we find ourselves led into zones which are either ignored or but superficially touched upon in what is contemporaneously known at Time and Motion Study. In discussing graduate work in the Methods and Standards area, therefore, we are defining the title broadly to include whatever we may be led into through fundametal investigation of the problems.

Objectives of Advanced Study

If a clear understanding of our graduate work is to be conveyed, it is perhaps desirable that we next define the objectives of advanced study. We believe that the qualified candidate for a graduate degree should possess a broad perspective of his general field and its functional relationship to industry and society, together with a critical comprehension of the problems and techniques within his area of intensive study. He should be able to plan and conduct original investigations and to report them in a manner which exhibits logical thought and competent use of the English language. These objectives are fairly well summarized as: background knowledge, analytic ability, and facility in communication. In addition to these there is one other objective for which we hold ourselves responsible. We must utilize the superior talent and abilities of our graduate students toward the fundamental advancement of the area. Considering the retarded development of this area in comparison with, say, Quality Control, we cannot afford to waste intellectual ability on trivial investigations, surveys, and the like. The record of the past several decades suggests rather strongly that we cannot expect fundamental development from the practioners in the area.

Having defined the objectives it next became necessary to decide upon the means for attaining them. From our original premises we came rather directly to the conclusion that the student's abilities should be directed into research on major problems. From this it followed logically that we must provide adequate facilities to carry out such research; that there must be a broad selection of fundamental courses to fit the student for his proposed research as well as to provide him with a broad perspective; that we must have graduate students with

* Condensed from two of the three papers presented under this title at the ASEE Annual Meeting in East Lansing, June 25–29, 1951.

ability and motivation commensurate to the task; and finally, that there should be opportunities for the type of faculty-student relationships necessary to carry such a graduate program to fruition. The remainder of our paper is an expansion on these points.

Coincident with the determination of a basic research policy we recognized that some sort of long-range planning was required. Establishment of a list of proposed research projects proved unsatisfactory, for what appeared to be a major project was sometimes revealed by susbsequent study to be premature or inadequately defined. We were headed in the direction of further contributions to the trivia with which the literature already abounds. This realization reoriented us away from the concept of neatly packaged thesis projects toward a scheme of basic programs having no predetermined duration and within which thesis work might be done as frequently and by as many students as the status of the programs from time to time should warrant.

Research Facilities

As some of our research programs began to develop it was apparent that we did not have adequate facilities for the work that we were embarking upon. We needed space where apparatus could be set up for the duration of a study, without interfering with our undergraduate laboratory work which was also expanding. We needed desk space for our graduate students at a time when there was insufficient office space for the staff. During this critical period the department augmented its permanent space to some extent, but mainly through an extensive study and re-allocation of existing facilities the space utilized by the Methods and Standards area was increased by 250% over the past five years.

Another sort of inadequacy in our facilities was equipment—particularly instrumentation. Actually, ours was about as good as would be found anywhere but the fact remained that the old standbys—the kymograph, marstochron, micromotion cameras, etc.—were obsolete for certain important types of studies. We were, and are increasingly dealing with multivariate phenomena. To generalize our findings with any degree of confidence it would be necessary to collect, in many cases, a rather respectable amount of data and subject them to extensive statistical analyses. The use of existing instruments for collecting these data would involve subsequently such an expenditure of clerical effort—such a waste of graduate talent—that we assigned a high priority to the development of modern instrumentation. Since modern instrumentation has become a specialized field in itself, it seemed uneconomical and even foolish that we should undertake this work ourselves. The problem was approached, therefore, by confining our efforts to the development of functional specifications which were then presented to electronics and instrumentation specialists in other Departments of the University. Thus, the Department of Electrical Engineering deserves major credit for the progress on some of our principal instrumentation projects.

A logical corollary to the instrumentation projects was the procurement of computing equipment to reduce the waste of talent in the clerical phases of data analysis. And along with these facilities we seemed to need another to reduce the time spent by students in organizing literature studies, collecting the material, and segregating from it that which was pertinent to their problem. Unfortunately, there was no service in this area corresponding to Psychological or Chemical Abstracts. The solution appeared to be a department abstract file for use of the staff and graduate students. Forms were designed and printed, and the file began to grow. Each student would check his study list against the file, using the abstracts to screen those titles which were listed. For all those not listed he went to the library and in the course of his study prepared abstracts which were in turn added to

the department file. Our original classification system, however, had been poorly conceived and soon became inadequate. Furthermore, we felt that mechanical sorting in addition to revised classification would greatly enhance the value of the file as a facility for graduate study. This work is now nearing completion.

Graduate Course Work

Thus far we have discussed a number of facilities which are important in our scheme of graduate work. To make effective use of these facilities in his individual studies, the student should be prepared through a program of course work tailored to fit his needs and abilities. To set up such programs there should be available a broad selection of fundamental courses. This requirement is satisfied in the large university, would be sometimes difficult to meet in the small college, and would practically never exist in the purely technical school. Some of our students, for example, take as many as 10 or 12 quarter hours in Experimental Psychology, others take a similar amount of course work in mathematical statistics beyond the calculus, or they may take minors in Economics, Physiology, etc. Another advantage of the University appears in the availability of top authorities in other fields to serve as special advisors on thesis research which has extensions into zones where we are admittedly far from being an authority. We have seen many instances where such on arrangement would have avoided a lamentable waste of research effort. Within our Department the descriptive approach has no place in the graduate level course. A student of graduate caliber does not require faculty assistance to digest descriptive material. The course work, therefore, is reserved for analyses of problems, dissection of contemporary methodologies and identification of the assumptions on which they are based, planning of investigations and analysis of results, study of research techniques and evaluation of research.

In short, the purpose of the course work is to mature the student intellectually, to construct a base from which he may continue to educate himself. In addition to an individually tailored plan of course work, the graduate student needs and is entitled to an opportunity for close contact with the faculty. The graduate program must be recognized as a process of developing the superior students and cannot be subjected to the administrative criteria for undergraduate teaching—such as, so many head per course-hour.

Our concept of an adequate graduate program, then, includes the establishment of fundamental research programs, the provision of facilities for the conduct thereof, a broad selection of graduate course offerings in the University, students with ability and motivation commensurate to the task (a point we have not detailed for lack of space), and an opportunity for close faculty-student relationships. The provision of these requisites is not merely a function of departmental staff endeavor, but of cooperation with other Departments and support of the Administration as well.

II. Graduate Work in Quality and Production Control

By LORING G. MITTEN

Instructor in Industrial Engineering, Ohio State University

This paper will concern itself with graduate work in the areas of Production Control and Quality Control in the Industrial Engineering Department of the Ohio State University. Particular emphasis will be given the relationship

between the graduate and the research programs in these areas. Two specific problems will be considered in detail:

1. The character of the field in which research is to be undertaken, and
2. The intellectual resources available for use in the research.

Meaningful research is not likely to spring solely from the "urge to research." Answers to the questions posed here are prerequisites to the design of specific research programs if fundamental contributions are desired.

Character of the Field

First, let us consider the character and degree of development of the field in which research is to be undertaken. On the one hand, there is Production Control which, from the basic research point of view, is almost totally undeveloped—it is a field which lacks fundamental unifying concepts and theories; a field abounding in rules-of-thumb, and in which practical experience substitutes for logical and rational method.

This situation offers great opportunity and at the same time a most difficult problem in research: opportunity because progress is possible in almost any direction: a problem because this same lack of an established basing point and direction gives rise to the necessity for really original and creative thinking.

Statistical Quality Control represents the opposite extreme. This subject is firmly grounded on well-validated basic theories and concepts, and its methods and techniques have been developed logically from these theories. Two choices faced us here: we could either concentrate our efforts on further elaboration of the basic theory and principles, or we could devote ourselves to the development and extension of practical techniques and methods from existing theory. We chose the latter alternative, and we now have a quite active group of research programs under way. For example, we have undertaken studies aimed at the development of new or simpler quality control techniques, at the introduction of economic considerations into quality control in a more explicit fashion, at extending the use of quality control techniques and the methods of mathematical statistics to new problems and new fields, etc.

The above discussion should serve to point out a basic fact: different fields of study have different characteristics and these characteristics impose definite conditions on the type of research which can be undertaken and the manner in which it must be carried out. We have had to recognize this fact in developing our Quality Control and Production Control research programs; the objectives and methods of execution of the programs have been tailored to the characteristics of the field in order to utilize our research potential to best advantage.

Intellectual Resources

We now turn to the second problem which arises in defining a research program—the question of available intellectual resources.

Probably the most important determinant of the type and caliber of research which can be undertaken is the capability of the departmental staff responsible for research work and graduate training. We have found that the greatest stimulant to creative and critical thought comes from assembling a staff with widely divergent backgrounds and training and giving them the opportunity to interchange ideas freely. To illustrate the benefits of this policy, let use briefly consider the course of development of one of our most significant accomplishments in Production Control—the formulation of a new theory of scheduling. A discussion of the inadequacies of present scheduling methods brought the problem to the attention of our staff mathematician. He formulated the problem in mathematical terms and was able to develop a solution to it. Later, as a result of discussions of this solution, another staff member was able to inter-

ject an economic criterion into the problem and thus further extend the utility of the results. The whole development was made possible only by the rather diverse abilities and viewpoints of our various staff members and by the free interchange of ideas among them.

Almost as important as the abilities of the departmental staff is the availability of expert, specialized knowledge outside the department. Any really worthwhile research program is almost certain to raise problems which cut across departmental lines and lead the researcher into fields somewhat foreign to his specialty. By far the most desirable solution to this problem involves consultation between the investigator and some individual who is thoroughly familiar with the specialized problem involved. There can be no question that the association of our department with a university employing top-ranking scholars in various fields is a distinct advantage in our research. For example, one of our Quality Control research programs involves an investigation of the factors affecting visual inspection performance. In the course of carrying out this investigation, we have consulted regularly with the chairman of the School of Optometry and with an expert in the Department of Psychology. Their aid has been of inestimable value in the successful execution of the project.

As the last factor in the problem of intellectual resources, we must consider the caliber and training of graduate students. The graduate student who contributes only physical and low level intellectual skills to a research program is being deprived of a vital part of his development and training, to say nothing of depriving the research program of the benefits of fresh approaches and individual abilities. If the student is to derive real value from the research phase of his studies, we must be sure that he has a proper background in the physical sciences, in engineering subjects, in mathematics, and in the social and life sciences.

Research in Industrial Engineering almost invariable involves a simultaneous consideration of physical and human problems. Machines are run by men; Production and Quality Control procedures are carried out by people and the procedures have a definite impact on those individuals responsible for the operations being controlled. If our research is to be meaningful, and if the results are to be of practical value, our graduate students must have a background which enables them to perceive and cope with the broad implications of the problems with which they are confronted. The so-called "broadening" subjects (such as psychology, physiology, sociology, etc.) are not merely desirable —they are absolutely essential; mathematical statistics and probability theory are musts; matrix theory gives promise of becoming a basic tool of great utility. We concede that no entering graduate student could be expected to be thoroughly conversant with all these fields, but we insist that he must have a firm foundation from which he can quickly build to the necessary proficiency.

The success of research is highly dependent on the intellectual capabilities of those planning, directing, and executing it. These capabilities must be honestly assessed and areas of strength and weakness delineated; the staff must be stimulated and their creative and critical abilities developed; strong ties must be forged with areas and individuals outside the department so that their expert knowledge can be brought to bear on problems; graduate students must have the proper background and training and their individual capacities must be used to the full. All this must be done consciously and vigorously if the graduate program is to yield significant research results.

Career Possibilities for the Teacher of Engineering Subjects*

By LOWELL O. STEWART

Professor, Head Civil Engineering, Iowa State College

The dictionary suggests that career may refer to a "profession or other calling demanding special preparation and undertaken as a life work." A poll of engineering teachers would, I think, elicit from many the statement that they just "happened to take up teaching." Few, if any, expected to make it a career. At one time I considered sending a questionnaire to engineering teachers to find out why and how they entered the field and how long they have been teaching. Returns from such a questionnaire would be interesting, they might have helped us to find a better answer to our question. We will have to be content with a qualitative rather than a quantitive study. Furthermore, I hope that this quick survey of the situation will stimulate discussion.

This brings us to the first point of our study: do the changing conditions in engineering make it necessary or desirable that we adopt a positive policy of selecting and preparing our engineering teachers of the future? These changing conditions may be summarized briefly as follows: For many years (in fact, prior to World War I) engineering was evolving from the art stage and there was heavy emphasis on empirical engineering practice. After World War I, and in particular since World War II, there has been increasing emphasis on the scientific aspect of engineering. We have reached a stage in that swing toward science where there are some who say that many of our engineering schools are now turning out applied mathematicians or applied physicists. A third stage in this evolutionary pattern is the increasing importance of science and technology in everyday life, and the growing number of engineers who reach executive positions where they are called to deal with important labor and industrial relations problems. Believing in the efficacy of course work we have set up courses in college where we propose to develop the student's ability to deal with and handle people.

The type of engineering teacher that we have needed and have called to our classrooms has paralleled the eras that I have described. When the emphasis was on the art and empirical aspect of engineering we needed men who had had a considerable amount of practical experience, men who knew and could teach how things were done in the field. Many of the older men on our staffs came into engineering teaching by way of this school of experience route.

Shifting Emphasis

As engineering practice moved from the art and empirical toward the exact science stage so did engineering teaching shift its attention. We began to hear more about research and graduate work Advanced degrees which had been a standard requirement for teachers in the arts and sciences for many years began

* Presented at Conference of Civil Engineering Teachers, ASEE Annual Meeting, East Lansing, Michigan, June 23, 1951.

to appear in engineering schools. The years since World War II have brought a large increase in the number of students who have earned advanced degrees in engineering. Some of this demand for more education was induced by the liberal provisions of the Veterans' Educational Programs. A substantial number entered graduate studies because they believed that the holder of an advanced degree in engineering would be able to find his way into types of work that were more profitable or more challenging than would be available to the holder of a bachelor's degree.

Presidents, deans, and department heads, sensing the changing educational picture in engineering, began to specify the master of science degree as a prerequisite, sometimes for appointment to any full-time teaching position, frequently as a requirement for advancement. It was a quick step from that stage to the present when we find that there is increasing demand that engineering teachers who wish to advance in rank and salary should have a Doctor's degree, frequently the Ph.D.

This demand that engineering teachers hold advanced degrees poses some important questions for the prospective teacher, for engineering education, and for the profession, and it bears directly on our subject, Career Possibilities for the Teacher of Engineering Subjects.

For the teacher there is the element of time and cost. To earn a master's degree requires approximately a calendar year and $1000 to $1500 cash outlay. The Ph.D. calls for three academic years of the candidate's time and several thousand dollars of his money. A popular way to work toward the advanced degree is to "learn as one earns" whereby the candidate teaches full-time or part-time while he carries on his graduate studies. Under such a program a full-time instructor might earn a master's degree in three years, and a doctor's degree in nine years. These periods could be shortened (at the expense of practical experience) if he attended summer school.

A quick consideration of the case of a typical young engineering graduate who is interested in a teaching career reveals that he should begin graduate work immediately after his baccalaureate degree. If he chooses to spend some time in gaining a few years of practical experience before he begins teaching he will face two strong factors that will deter him: one will be his salary and family responsibilities; the other will be the attitude of presidents and deans. He will find that his salary in industry has reached a level substantially above that which he will be offered in college teaching, and his family responsibilities preclude his accepting a cut. Presidents and deans with the best of intentions and desires to employ promising young engineers with experience will be unwilling to pay the salary that is needed, and they will seek men with advanced degrees.

This trend toward increasing emphasis on research and graduate study with advanced degrees as a prerequisite for engineering teaching, and decreasing attention to what we commonly call practical experience—the practicing of the profession—has important implications for engineering education and the engineering profession. As the courses of our engineering curriculums become more theoretical and "scientific," it follows that the professional engineers who learn from that course work will lean toward the "theoretical" rather than the "practical," resembling more and more the European engineers.

This swing away from the "practical" might go too far. Our engineering teachers must maintain more than a speaking contact with engineers on the job. They can have the advantages of advanced education without foregoing the benefits that come from "practical" experience. I suggest that this may be accomplished if the preparation of our engineering teachers includes: (a) summer work in industry, (b) consulting experience where possible, (c) sabbatical leaves for work in industry, (d) engineering registration, (e) active participation in techni-

cal societies, (f) some training in the techniques and business of teaching. The carrying out of the "work in industry" portion of this program will require the understanding and willing cooperation of many companies who employ engineers. This is not a new idea. It should be carried out on a larger scale than it is at present.

Educational Methodology

It is well known that college teachers have been uninterested, generally, in studying courses in educational methodology as a device for improving their own teaching. On the other hand, there are Educationists who would require college teachers to study several courses in Education, and qualify for a teaching position by certification. Teaching is an art and a profession. Surely there are principles and techniques of good teaching that can be taught, and need not be left for each teacher to discover for himself by trial and error. I think that every engineering teacher should have some effective instruction and direction in the principles and methods of good teaching. This may be done by taking course work, by observing good methods of experienced teachers, and by personal study. Perhaps it is true that good teachers are born, but it does not follow that good ones cannot be made.

Will this young man find a teaching position? We are entering a period of low college enrollments, a result of the low birth rate of the 1930's. However, the high birth rates of the early 1940's will bring a crop of high school graduates in the 1960's which will be considerably larger than the 1951 crop. From this increased number of high school graduates there should come more college students than we have in 1951, unless the American youths of that decade set values on a college education which are different from that given it in the past. We Americans have gone to college because it offered vocational or professional training with a good salary: because campus life is unique; it has some of the competitive aspects of life on the outside, yet it is idealized and controlled and protected so that the student does not pay heavily for his mistakes: and, because there is opportunity to satisfy intellectural curiosity. Perhaps some of the economic changes of this quarter century, which finds incomes of skilled workmen higher than that of college-educated men, may have some effect on college enrollment. However, the long-term trend toward college attendance by an increasing number of high school graduates is likely to go on, with continuing emphasis on science and technology. This, in turn, will call for more college teachers.

There will be enough opportunities so that, in general, well qualified engineering graduates will experience little difficulty in finding a teaching position. There is real danger, however, that too few of the able young men who are needed will see the desirability of making a career of engineering teaching. Many engineering colleges have had difficulty in recruiting the type of man they would like to place in teaching positions.

Rewards of Teaching

It is pertinent at this point to consider the rewards of teaching and the qualities of a good teacher; to explain what seems to be a paradox, namely, that teaching is one of the medium salaried arts and professions, yet it calls for men with high abilities and strong personal traits. Some wag has said that "those who can, do; those who cannot, teach." That is a slanderous statement which expresses the opinion of many poorly informed people. The truth is that the teacher, at all levels of instruction, carries a heavy responsibility. He is expected to be expert in many subjects particularly in his major field of specialty; he must be a good citizen, a good example for other citizens; he should have no vices; it is presumed that he will be able to teach all types of students effectively;

many students and parents look to him for all kinds of counsel and advice in technical, professional and personal matters.

Yet the teacher does receive a lower salary than his equally able classmates who make their careers in industry. Each year most of the ablest men of the graduating class take engineering jobs. Perhaps they have had enough of college life and wish to go out to make their way as they had planned. Possibly, there are instances where students gained the impression from their teachers that teaching would not be a desirable career. Maybe the difference in salary is a measure of the risks involved, the thought being that the man in industry faces a greater probability of losing his job or of taking a cut in salary than does his classmate on an engineering college faculty.

What are the great rewards of teaching? We will name three important ones. There are others. The teacher has leisure; he is using his mind on valuable subjects; and, he has the satisfaction that comes from making something.

Leisure according to the dictionary means "freedom afforded by exemption from occupation or business; time free from employment." Some one in a facetious or misanthropic mood after a particularly frustrating day of wrong answers or poor reports might question the soundness of our assumption that the teacher has leisure. This person forgets, perhaps does not know, that anyone in any field of work has his moments of discouragement and feeling of overwork. The fact is that the typical teacher of engineering subjects, who knows how to plan his work, has many hours when he can do interesting and exciting things (as long as he remains a teacher and does not move over into the area of administration). He can write books and technical articles; he can carry on research projects; he can accept assignments to help on committees of technical and professional societies; he can do consulting work on challenging problems in his field; he can accept election, on public and semi-public boards; he can spend profitable moments counseling students and pleasant hours reminiscing with alumni; he can take interesting, useful, and restful vacations. Other people do these things too, but the teacher has a flexible time schedule which does not call for an eight to twelve and one to five o'clock daily appearance on the job. During these periods when he has no daily chores he can use his time as he chooses; and that is leisure.

The teacher is using his mind on valuable subjects. Whether a given subject is valuable may bring difference of opinion and debate. Yet the matters that are the daily tasks of the teacher have become established as important by common consent. He studies and teaches the works of the great mathematicians, physicists and chemists and applies their principles to the solution of current problems. He learns the fascinating story of the development of engineering from simple observed happenings to the present-day body of knowledge. These studies help to introduce him to the newer discoveries that have come after Einstein and most recently nuclear fission. And there are the great works in the humanities and the social sciences as well as the new ones that appear daily. All of this he does as a part of his daily job. Is there any doubt that he uses his mind on valuable subjects?

The third reward was the satisfaction that comes from making something. Again we can point out that many people make something from which they gain satisfaction. The teacher's reward is akin to that of parents as they watch young people develop under their guidance. Every teacher has experienced the joy of seeing a young person grow under guidance from a rough, untrained but eager youngster into a smooth, careful thinking and effective man or woman. And several years after graduation when they return as successful engineers to tell about their work, often times bringing

their families, the teacher has his supreme reward.

Qualities of Good Teachers

This is a good place to mention the qualities of a good teacher because there are only limited career possibilities in teaching for the young man who does not have them. The teacher must know his subject. If he is to do better than "just keep ahead of his students" he must understand the rudiments of his subject thoroughly. To do this he should know the subject in its higher or advanced levels. That's one of the good reasons why a young teacher should pursue graduate work and research. Young people have an infinite capacity for asking questions and the teacher who is not prepared to answer questions in the ranges above the current work level will not do a complete job.

The teacher should like teaching, although there might be some minor details that he dislikes. He must have the will and patience to prepare himself thoroughly in some subject matter fields that are close to his. He should enjoy the daily business of lecturing; leading discussions; asking thought-provoking questions, written and oral; preparing problems and examinations, and correcting them after they are written.

It follows that he must like students and enjoy their company, both the good ones and the bad ones, and he must keep the relationship impersonal. He should believe in the basic goodness and worth of the individual. He cannot force his students to learn. Teaching and learning call for mutual confidence and respect. There aren't many instances where there has been learning in an atmosphere of mutual dislike.

There are several desirable personal traits: the teacher should have a sense of humor; he should have a good memory; will power and self control; a kindly and friendly manner.

Before closing this list of teacher traits I wish to mention something that has worried me a good deal recently. It seems to me that young teachers are reluctant to do a bit more than they are paid for. Is this just a figmant of my imagination? If true it must be another sign of a point of view which seems to say that we can have something for nothing. But teachers, above all, should be exponents of a sterner philosophy. This ideal of the true professional man is well described by the late William E. Wickenden in his paper, "The Second Mile," * in which he takes as his text from The Sermon on the Mount, "Whosoever shall compel thee to go one mile—go with him twain."

The Dollar Problem

There are some factors that are not entirely favorable to the proposition of a greatly expanding teaching staff. Educational costs have been rising along with other costs. Publicly supported institutions of higher education find themselves competing for the tax dollar with a number of lustily growing newcomers. For example, the Iowa legislature appropriated for 1951–52 very nearly as much money for Social Welfore (Aid to the Blind, Aid to Dependent Children, Child Welfare, Emergency Relief, Old Age Assistance—by far the largest of this group) as it did for higher education. Moreover, these social welfare requirements will increase each year. Taxpayers are becoming tax conscious but they are not well or adequately informed about the uses of their tax dollar. Higher education could lose in the race for its needed share of that dollar.

The income situation for privately supported colleges and universities is more precarious than that of the state schools. Fixed incomes from endowments are falling behind needs as the purchasing power of the dollar falls. Furthermore, income taxes are taking for the government large sums that used to be available for gifts and endowments. So these schools, like the state schools, are hard pressed

* *A Professional Guide for Junior Engineers,* ECPD, p. 44.

to find enough money to pay high-enough salaries to as many teachers as they need.

Another factor that may affect the share of the budget that will be available for teaching is the rapidly increasing amounts of money that are spent on research. This should have no depressing effect on the total employment of engineering graduates because those who do not teach could do research. A conflict for funds between teaching and research may arise in about ten years when the high school graduates of the 1960's enter college.

A third factor in the apportionment of the educational budget is the increase in administrative costs. Some of this comes from increased services to the students, such as counseling, personnel and employment departments, testing bureaus, and others Some of it is spent for assistant deans and other administrative assistants and for stenographic help for these assistants. Looking at this matter from the standpoint of employment opportunities for engineering graduates in the educational field one might say that it is on the "plus" side. But it does reduce the portion of the budget that is available for teaching.

Generally, unit costs in education have been rising steadily. Teaching loads (student contact hours or similar units) are smaller than they were a few years ago. Class sizes increased during the recent heavy enrollment period but they are returning to normal now. Some schools are operating on a five-day week (no Saturday classes). There is less committee work and other extra-curricular assignments for the teachers (assistant deans do some of this). All of this is favorable from the selfish point of view of the individual teacher. But it may be unfavorable in the overall effect if costs become so high that money cannot be found to carry on at that level of operations.

Recent developments, hastened by tensions of the war years, have brought into sharp focus a matter that has had little attention from teachers of engineering. I refer to academic freedom and tenure. In some states public employees, including teachers, have been required to sign oaths, commonly designated Loyalty Oaths. In the main, teachers of engineering have shied away from any connection with the American Association of University Professors who have carried the burden of the fight to maintain academic freedom and tenure for the teacher. This is truly a matter of fundamental importance because they are the principles that guard our freedom as citizens. Institutions of higher education are conducted for the common good and the common good depends upon the free search for truth and its free exposition. Teachers of engineering and of science have assumed that they deal in facts, and facts are not controversial. Yet we have seen governments and states set up an official and, therefore, a so-called true and correct set of facts.

In summary, we have pointed out that teaching offers significant rewards to those who have the qualities of a good teacher; that there is increasing demand that teachers hold advanced degrees which implies stronger emphasis on science and theory; that this calls for stronger efforts of the teacher to acquire knowledge of engineering practice; that there seems to be a need for a defined program for recruiting and training teachers of engineering; that there will usually be places for competent engineering teachers; that college enrollments will increase in the 1960's which will require more teachers than we have now; that increased educational costs and competing requests for the taxpayer's dollar leave smaller amounts for educational purposes.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	Carnegie Institute		E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oncken, Jr., Bureau of Ordnance
*New England		May 10, 1952	E. T. Donovan, University of New Hampshire
*North Midwest			S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
*Pacific Northwest	Seattle		T. H. Campbell, University of Washington
*Pacific Southwest	Los Angeles San Francisco	April, 1952	S. F. Duncan, University of Southern California
*Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952.	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
*Upper New York	Clarkson College		W. H. Allison, Clarkson College

Members of the Society are welcome at all Section Meetings

* No Date Set.

The Non-Engineer Looks at Engineering Students*

By A. M. BUCHAN

Professor of English, Washington University

The topic of this talk is not one of my own choosing. It was assigned by your committee. Dean Stout may have chosen it, knowing that one of my chief interests for a number of years has been a desire to make literature palatable and useful to young engineers. It has not been a very grateful task, because the notion still persists that it cannot be done. Unfortunately, too, the heads of English departments, vain of scholarship only, often assign to the engineers the duller members of their staff, and, if the teacher is dull, not even literature can be made exciting.

The distinction, however, in the title, between the engineer and the non-engineer is one that leaves me unhappy and unpersuaded. There is an old Scottish proverb that says, "We are a' Jock Thomson's bairns," and it is to the children of Jock Thomson, human children very much alike in moods and aspirations, that we direct our education, including that part of it which has to do with spiritual and personal security. Engineer and non-engineer find in literature, and perhaps in literature only, the kind of training in idea and mood that gives meaning to the techniques as well as to the arts.

In fact, as I recall my friends who are engineers, they are not markedly different from myself and my literary acquaintances. They are quite at home conversing with educators or physicians or lawyers or business-men about affairs in Iran or Korea. They work, during some part of their leisure, on the same community problems, being concerned about the kind of school or church or swimming-pool their children frequent. They are interested, within and beyond their specialties, in similar topics, debating the relative merits of a Buick or an Oldsmobile, an apartment or a house in the country, a vacation in Colorado or in Maine. In their personal lives they pursue the same goals, a desire for respect and independence, and a hope that courage will endure if security fails.

Even in the world of social appearances, the effort to segregate the engineer from the non-engineer implies a distinction that is almost half a century behind the times. Long ago the engineer graduated from the overalls and rough high boots of the surveyor's helper. He wears the white collar of his profession, and, in practical affairs, he teams up with the economist, the architect, the social worker, the advertising man, even the clergyman. To some extent, he assumes his share of the responsibility of each one of these, and, while the details of his contribution to society differ from theirs, they and he require something of the same training and the same kind of manhood.

And, just as the gap has been bridged between the old rough engineer and the more polished member of the older professions, so the distinction between engi-

* Presented before the Missouri Section of the ASEE, University of Missouri, April 7, 1951.

neering students and other students in the college or the law school or the school of business seems to be disappearing. When some of us started teaching twenty-five years ago, we had a general impression that the boy who elected engineering was a rather different breed of animal from the usual college boy. On the surface he did not display the same superficial gloss. His clothes were often untidy, and his manners were deliberately rougher and a little uncouth. He scorned some of the light-hearted gaiety of the campus, because he was pledged to more serious and masculine pursuits. But that engineering student of some time ago—and he was a likable lad, in spite of being consciously a diamond in the rough—is not very common any more. In general, the student of engineering is no longer, if ever he was, essentially different from any other liberal or professional student. There comes into schools of engineering a representative selection, I believe, of the student population of the country.

Intellectual Categories

When in the fashion of the pedagogue, I divide my students into categories, I place them in three simple groups. There are, first, the brilliant ones whose abilities we admire and envy. They come, for the most part, from good homes and good high schools. Having been accustomed at home to hear literate talk and to read wisely, they adjust to courses in speech and composition and literature as naturally as to math and chemistry. They are blessed with the greatest gift of the college student, a fine abstract intelligence, and they find little trouble in any branch of study. With their kind of intellectual equipment, they discover that the applied courses of their junior and senior years in engineering school are almost elementary once the theoretical foundations have been laid in math and physics and chemistry. In medicine or law, in English or thermodynamics, this type of student excels.

Theoretically, it is almost impossible to overwork the brilliant student. His capacity to assimilate and to use information is tremendous, and his instructors, suspecting this, load more and more technical courses on him during his later years in school. My own personal judgment, as a teacher of literature, questions the justice and wisdom of such a policy. For this kind of young man stands to profit far more than the average person, at this stage of training, from the leisure that his active intelligence has earned for him. As a junior and senior he should have the option within the curriculum of reading widely in history and economics, even of acquiring another language if he prefers, so that the required professional courses will merge, as his professional work will, later in life, into a wide personal and social context. He should have a chance to read and to discuss whatever finer issues appeal to him, and he should have on hand as his guides teachers who remember that a profession is only as great as the personalities of the people who man it.

The second group of students, the mass of low B's and C's, has considerably more of a handicap. Many come from homes where magazines substitute for books and in which conversation is casual and slovenly. The broad fields of history and literature and the basic sciences have been covered at breakneck speed in high school so that very little of their significance stays in the memory. It is often an almost completely fallow mind that these average boys bring to college, clumps of weedy interest appearing in a wide expanse of boredom. Their classes in math and physics, though they begin on an incredibly elementary level, keep them very busy, and classwork in the humanities seems an unnecessary intrusion on precious study hours.

It is only being realistic to concede that these slower students have an argument against too much classwork in the humanities. Immersed in calculus which they must learn, they resent Somerset Maugham's *Of Human Bondage* which is only a single option among a thousand. Perhaps part of an answer is the one we

have tried in Washington University of substituting infrequent conferences for regular class sessions, and an optional for a required reading-list. A program of this sort, added to the obligatory training in speech and composition, is a frank recognition of an aim—that it is better to have a student continue to like reading than to cram a mass of distasteful books down his throat.

At the bottom of the college heap is a third group, a number of stupid and sometimes friendly lads for whom not a great deal can ever be done. They lack the range of intelligence that makes possible an outlook broader than the immediate task. The profession of medicine has for some time been rejecting such lads by a variety of screening processes, and they are beginning to find themselves excluded from schools of law. In the college and the school of engineering we still put up with a few of them, hoping for a miracle. But our hope usually stops short of a diploma, and we waste time and prejudice the standards of the profession by setting the hope too high.

This division of students has no particular value except to sharpen my point that the engineering school, like the college or the business school, enrolls a number of the three kinds. We who teach English have had students of engineering who were perfectly at home in advanced courses in literature, whose minds were philosophic as well as pragmatic, who were broad-gauge young men as well as expert technicians. We have also taught, in the college of liberal arts, young men and women who would be as helpless in the presence of a centrifuge as they are in the company of a simple sentence.

Distinctive Characteristics

It may be possible, however, to suggest one or two areas in which the engineering student does appear to have a mark of difference. His distinguishing qualities are almost certainly indications of different interest rather than of different capacity, and they are mentioned because they seem to point in the direction towards which the study of language and literature should move in technical education.

1. The engineering student is less inclined to "verbalize," i.e., to put his ideas into words, than the college student. Used to the precise terminology of mathematics and the sciences, he shies away from words that are vague and indefinite. He can define a cosine, he is not so positive about a lyric. He knows what ought to be written about an experiment in chemistry, but he doubts whether it is worth while to give his impressions of a novel or a character in history.

Perhaps he unconsciously believes that some impressions are to be felt and not put into words, that they are obvious and do not need words. He may even suspect that the abstract vocabulary of the social and humane studies muddles rather than clarifies the mind, and in this suspicion he may be justified. Somehow, though, he must learn that much of human relationship is carried on, and must be carried on, by means of words and phrases that are not precise like the symbols of science. When he goes into the world out of the lab, he needs some facility in the hit-or-miss communication of ideas, and his speech and writing must be disciplined to meet this need. He must learn, that is to say, to communicate, in his social and personal life, by words, as well as in his technical life, by graphs and statistics. These fashions of communication are, of course, the basic substance of our courses in English.

2. Linked with this reluctance to verbalize is a happy circumstance about the technical student—and about mature engineers, too—a refusal to accept some ideas at their face value. Among the ideas he is inclined to reject are some that appeal strongly to the teacher of literature. The man of letters usually prefers his mental cocktail flavored with a dash of mysticism, and his eye is more attuned to the nuance than to the trim outline. In a sophomore college class, the young English instructor becomes excited about wandering lonely as a cloud and admiring

a host of daffodils. His engineering student is as apt as not to feel slightly nauseated under these circumstances.

The difficulty does not lie with poetry itself or with an incapacity in the student to admire daffodils singly or in quantities on a field. Engineers, as I know them intimately, are not at all less sensitive than teachers of literature to the beauty of a flower or a sunset or a human face. Many of them are camera experts and take a natural delight in color and form and the beauties of old association. But they are slow to read into a field of daffodils or any other scene the mystical philosophy of a Wordsworth or a Thoreau. They look for more immediate and more practical values.

This pragmatic approach to ideas is, in some ways, of high critical importance. It has the merit of rooting an idea in the facts of one's own experience. A student of mine, for instance, a veteran, became interested, through his course in reading, in the psychology of Alfred Adler and the now familiar notion of the significance of inferiority attitudes during the early stages in life. He began his report by outlining the Adlerian theories and then suddenly branched off into a discussion of his own two children, aged five and two. He explained how they had been parked on their grandmother and were beginning to show the symptoms that Adler described of the neglected and insecure child. As he spoke, his analysis of Adler became a scrutiny of his own family problem, and from a book on psychology he took guidance towards the important decision to set up housekeeping again for the sake of his children.

3. The engineering student, then, is restive in the presence of ideas as such and seeks some practical application of them. He takes a similar attitude towards his own career. Quite early and usually in complete sincerity, he directs himself towards a practical goal. He is aware that an engineer makes a good living and has a substantial place in his community. So, as a young man, he concentrates much of his effort on practical lines of ambition, and other needs, less obviously useful and immediate, have to be justified in his eyes.

Doubting Thomas

So that we who are responsible for the humanities must be perfectly candid in our teaching. Though we are convinced of the worth of history and literature and economics, the student of engineering may not agree with us unless and until we are prepared to prove our case. Our specialties seem to him to be unessential, icing and not cake, decoration and not structure. If we are to make them acceptable, we must spend part at least of our inadequate teaching time trying to show why some books are worth reading and how the record of the past helps to make the present understandable. In an engineering college we are not teaching students who will take what they are given so as to regurgitate it, grade-wise, in examinations. The engineering student is a professional doubting Thomas asking for proof of a miracle.

These marks of difference in him—his reticence, his practicality, his drive towards a manageable goal—would not be worth mentioning if his education were merely a training for a job. His refusal to be sidetracked, in fact, could easily be a guarantee of his future success. But few teachers of engineers would be willing to interpret education so narrowly. There is another world for engineering students besides that of practical aims. Within him resides the life of his mind and spirit. Around him revolves the similar life of his friends, the life of human contacts.

At this point, it is necessary to part company with the students, and to speak rather of those who are now engineers and teachers of engineers. For only to the extent that engineers, men engaged in the teaching and practice of the techniques, prize this personal life and this life within the community will any measure of its importance be reflected among the young men who are still being taught.

A hint comes to me, now and then, of the technical man's attitude. A common friend introduces me to an engineer. After the names are given, the engineer asks, "And what is your line?" "I teach English," I reply. Invariably—and it has happened so often as to be amusing—the engineer remarks with a smile, "Oh, oh! I'd better watch my grammar," or "It's years since I read *Hamlet*. Do you still read it in school?"

Such a remark may seem trivial but it reveals a great deal about the speaker. Uttered as it is, smilingly, it is half an apology and half a gesture of defiance. On the one hand, it asks humble forgiveness, as from a school marm, for a split infinitive which is not important. It suggests regret for books that have not been read and for ideas that no longer occupy or interest the mind. At the same time, it implies that the literature and ideas, to which the teacher of the humanities devotes himself, are not of much significance to active, energetic men.

Cultural Deprivation

The note of defiance, I believe, can be overlooked. Every one of us, denied the chance of doing more than one thing reasonably well, is inclined to resent the different competence of a neighbor. But the engineer's tone of deference is another and a stranger omen. In remarks like the ones quoted, he is paying tribute to areas of education, the practice and enjoyment of which have been denied him by the narrow scope of the engineering curriculum. If we wished to be psychological about it, we'd say that the engineer suffers from a feeling of guilt or inadequacy. Friendship with a teacher of humanities—I'm dreadfully sorry that it should be so—makes him acutely aware, not of his advantages only because these are obvious, but of his shortcomings.

What is it that my friends who are engineers imagine they have missed along the way of their training? Put simply, it is a wider and deeper familiarity with literature, the arts, and the nebulous fabric known as culture. They wish there could have been more leisure for music, painting, and the reading of non-technical books. Some of them even hanker after the minor fruits of culture, an easy manner among people, a fluent tongue when the conversation turns to politics and social affairs. Almost every one gives evidence of his regret that valuable opinions and attitudes and ideas were denied him in the course of his training. He has been kept from a heritage which is rightfully his as a professional man.

Let me confess that few of my engineering friends are satisfied with their deprivation. One devotes himself to music and allays his sense of guilt, as the psychiatrists say, in trying to master the piano. One gives a great deal of his leisure, of which he has little, to the affairs of the local school in which his children are pupils. One allows his wife to serve as a substitute teacher at the expense of her housekeeping and the promptness of his evening meal. Others take every opportunity to drop in on those of us who have leisure to read, so that they can participate in the give-and-take of intelligent talk. Alongside the technical magazines that come home from the office and the sheets of specifications that come from the job is a stack of "Harper's" on the engineer's library table or a modern novel that he hopes he can find time to read some day.

This desire to compensate, this hunger for they know not what in the way of personal cultivation, is the reason for my friendship with engineers and for my belief that their training should contain large elements of the humanities. The student of engineering should be given as generous an opportunity as the curriculum affords to know and like literature, and to be encouraged to speak freely about ideas. He should not leave college with a grudge against it for never having opened to him a whole wide range of social and personal values. In some

degree he should always have a sense of inadequacy, since it will keep him hungry for what is still to be known, but he deserves some guidance and stimulation in the great impracticalities of living.

He may not be able to read many books but he can be given so as to retain it the capacity to enjoy a novel or a play. He should be encouraged to find excitement in a world of ideas not directly related to any occupation, and even in things too imaginary to be realized. Somewhere in his training, too, he ought to learn that one way to keep his interest in people and society awake is to try to express this interest in words and stories.

He may learn, also, that a sensitiveness to literature and art is nothing to be ashamed of. His reticence is, in some respects, a virtue, saving him from the sheer gush of the college sophomore. But an emotion that is never expressed may dry up completely, and an idea that is not discussed may lose its charm. The personality of the student—this is an element in his education, and engineer and non-engineer alike have a stake in its development.

Sections and Branches

Report on North-Midwest Section Meeting of American Society for Engineering Education

Eighteen technical papers and reports held the interest of some 200 members of the **North-Midwest Section** at their annual meeting at the University of Wisconsin, October 5 and 6.

Professor Olaf A. Hougen, Chairman of the Department of Chemical Engineering at Wisconsin, who recently returned from a year's service as a Fulbright scholar in Norway, where he taught at the Trondheim Technical School, was the main speaker at the annual dinner on October 5. He gave an illustrated talk on his extensive travels in Norway. Other speakers at the dinner included Dean Morton O. Withey, toastmaster, and Dr. Ira L. Baldwin, vice-president of academic affairs at Wisconsin.

In addition to the various divisional meetings on Saturday, October 6, Professor L. O. Stewart, Iowa State College, lead a general session on society affairs. This innovation was well received by the members.

Elected to serve as officers for next year are:
Chairman: S. J. Chamberlin,
Vice-Chairman: A. B. Drought,
Secretary-Treasurer: Wm. C. Alsmeyer,
Council Representative: Kurt F. Wendt.

TIMELY TIPS

Some Remarks on Envelopes

By H. W. BRINKMANN and R. A. ROSENBAUM

Professors of Mathematics, Swarthmore College

The following problem, which arose in a class in descriptive geometry, leads into questions which may have some pedagogical interest: If a flaring surface, like an old-fashioned phonograph horn or (with rather different dimensions) a modernistic lamp-shade, is generated by revolving the arc, AB, of a plane curve about an axis in the plane of the curve, what are the orthogonal projections of the surface? The projection on a plane, π, for example, is simple if the axis of revolution of the surface is either parallel to π or perpendicular to π, but how does one determine the so-called "curve of visibility" of the surface for other orientations of the axis?

If π is vertical, if the phonograph horn is placed with its axis vertical and with the small end below the large, and if the axis is then tipped back, say $\theta°$, $0 < \theta < 90$, in a vertical plane perpendicular to π, it is intuitively clear that the curve of visibility, C, will start somewhere on the ellipse which is the projection of the circle generated by A and may end before it reaches the ellipse which is the projection of the circle generated by B. In fact, C is at least part of the envelope of the family, F, of ellipses which are the projections of the circular sections of the surface, and the phenomenon described in the preceding sentence is related to the fact that not all members of F necessarily have real contact with the envelope.

Envelopes of Families of Curves

Examples of families of curves not all members of which have real contact with the envelope of the family are considered in standard text-books—on differential equations, among others. For instance, the envelope of the family of circles,

$$f(x,y,\alpha) \equiv (x-\alpha)^2+y^2+\alpha^2-k^2=0,$$

is the ellipse

$$\frac{x^2}{2k^2}+\frac{y^2}{k^2}=1.$$

Here there are real circles of the family for $|\alpha| \leqslant k$, but the circles for $|\alpha| > \frac{1}{\sqrt{2}}k$ do not have real points of tangency with the ellipse.

The following three-dimensional picturization may often be helpful to the student and may be especially useful in helping him to visualize the situation outlined in the above example.

If the surface $f(x,y,z) = 0$ has a "projecting cylinder," $F(x,y) = 0$ (i.e., a cylinder with an axis parallel to the z-axis enveloping the given surface), then the curve $F(x,y) = 0$, in the xy-plane, is the envelope of the family of curves $f(x,y,\alpha) = 0$. (The curve of visibility, to go back to the terminology of section 1, is part of the envelope of a family of contour lines.) Furthermore, if there are real sections of the surface $f(x,y,z) = 0$ for $z_1 \leqslant z \leqslant z_2$, while all real points of tangency of the cylinder, $F(x,y) = 0$, with $f(x,y,z) = 0$ are included in the range $z_1' \leqslant z \leqslant z_2'$, where $z_1 < z_1'$, or $z_2' < z_2$, or both, then there will be curves of $f(x,y,\alpha) = 0$ which do not have real contact with the envelope.

In the example with which this section was begun,

$$f(x,y,z) \equiv (x-z)^2+y^2+z^2-k^2=0$$

is an ellipsoid so oriented that horizontal sections of the surface are circles. It is easily seen that z is limited to the interval $[-k,k]$. The projecting cylinder has an elliptical cross-section; points of tangency with the ellipsoid are restricted to the range $-\frac{1}{\sqrt{2}}k \leqslant z \leqslant \frac{1}{\sqrt{2}}k$. For $-k \leqslant z < -\frac{1}{\sqrt{2}}k$, and for $\frac{1}{\sqrt{2}}k < z \leqslant k$, the circular sections of the ellipsoid all lie within the projecting cylinder.

Example

We return now to the problem of section 1. Suppose, as an example, that the phonograph horn is generated by revolving about the vertical y-axis the arc of the curve $ky = x^{2/3}$ from $y = a$ to $y = b$. If the surface is tipped straight back $\theta°$, $0 < \theta < 90$, the circular sections of the surface will project onto the frontal plane π as ellipses. The circular sections at a distance p above the origin will have a radius of $(kp)^{3/2}$; hence, the equation of the family of ellipses will be

$$f(x,y,p) \equiv \frac{x^2}{k^3p^3} + \frac{(y - p\cos\theta)^2}{k^3p^3\sin^2\theta} - 1 = 0. \quad (1)$$

Differentiating with respect to p, in order to obtain the envelope, gives

$$f_3(x,y,p) \equiv 2(y - p\cos\theta)\cos\theta + 3k^3\sin^2\theta \cdot p^2 = 0. \quad (2)$$

Equations (1) and (2) are parametric equations of the envelope, with p as the parameter; when they are solved for x^2 and y we have

$$x^2 = k^3p^3 - \frac{9}{4}k^6\tan^2\theta \cdot p^4,$$

$$y = \cos\theta \cdot p - \frac{3}{2}k^3\sin\theta\tan\theta \cdot p^2.$$

It is found that, for $p = 0$, $\frac{dx}{dp} = 0$, $\frac{dy}{dp} \neq 0$; and, for $p = \frac{1}{3k^3}\operatorname{ctn}^2\theta$, both $\frac{dx}{dp}$ and $\frac{dy}{dp}$ are zero. The shape of the envelope is approximately that of the accompanying figure, where 0 corresponds

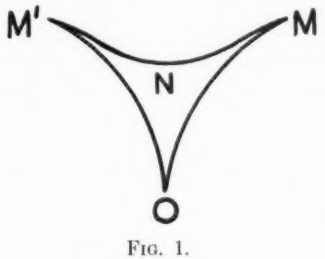

FIG. 1.

to $p = p_0 = 0$, M,M' correspond to $p = p_m = \frac{1}{3k^3}\operatorname{ctn}^2\theta$, and N corresponds to $p = p_n = \frac{4}{9k^3}\operatorname{ctn}^2\theta$. If $a < p_m < p_n < b$, then we have the curve of visibility for $a \leqslant p \leqslant p_m$, there are points of tangency, hidden unless the surface is transparent, for $p_m < p \leqslant p_n$, and no real tangency of the ellipses with the envelope for $p_n < p \leqslant b$. The critical value, p_n, has a simple interpretation in terms of the original generating curve, $ky = x^{2/3}$. For this curve,

$$\tan\phi = \frac{dy}{dx} = \frac{2}{3kx^{1/3}} = \frac{2}{3k^{3/2}y^{1/2}} = \frac{2}{3k^{3/2}p^{1/2}},$$

or $p = \frac{4}{9k^3}\operatorname{ctn}^2\phi$. A comparison of this with the expression for p_n shows that real contact of ellipses with the envelope occurs only for those members of the family generated by points on the original curve where the inclination is not less than θ, the angle of tipping.

TIMELY TIPS

Comparison of Thermal Efficiencies of Rankine and Regenerative Steam Power Cycles

By SEYMOUR COMASSAR

Lieutenant, USNR, Department of Marine Engineering, United States Naval Academy

Abstract: A simple proof to show that an ideal regenerative steam power cycle must have a greater thermal efficiency than an ideal Rankine steam power cycle operating between the same pressure and temperature limits is described.

Prior to the study of the regenerative cycle, it is usually brought out that in comparing a reheat steam cycle with a simple Rankine cycle operating between the same pressure and temperature limits, the reheat cycle produces a greater work output but also requires a larger heat supply. Under these conditions, the thermal efficiency of the reheat cycle may be greater than, equal to, or less than the thermal efficiency of the Rankine cycle, depending upon the reheat pressure and temperature selected.

In comparing an ideal regenerative cycle with a Rankine cycle operating between the same pressure and temperature limits and with the same weight rate of flow to the condensers, the regenerative cycle also produces a greater work output and requires a larger heat supply. The fact that the thermal efficiency of the regenerative cycle must always be greater than the Rankine cycle under these conditions is not always obvious

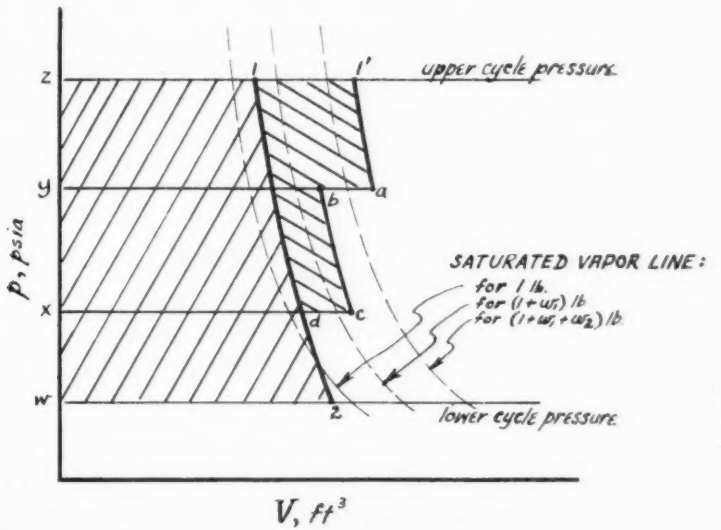

FIG. 1.

to the student, especially on the basis of the prior comparison of the reheat and Rankine cycles. A proof of this fact follows.

Compare the regenerative and Rankine cycles on the basis of the same pressure and temperature limits and *equal flow rates to (and through) the condensers.* Therefore the specific values of the properties of the steam in both cycles will be the same at the turbine inlet and exhaust and at the condenser inlet and discharge. The weight rate of flow to the regenerative cycle turbine will be greater and therefore its work output will be larger than the Rankine cycle turbine. The heat rejected to the condenser circulating water in both cycles will be equal. If all pump work in both cycles is neglected for simplicity (pump work is not equal in the two cycles but the difference is negligible) the work output of the turbines is equal to the net work of the cycles and these work quantities can be shown as areas on p-V coordinates as in Fig. 1.

In this figure, line 1–2 represents the isentropic expansion in the turbine of the Rankine cycle and the area 1-2-w-z is the work output of this turbine ($\int_1^2 V dp$). Utilizing a regenerative cycle with two extractions for feedwater heating, the lines 1′-a, b-c, and d-2 represent the expansion of steam in the turbine of this cycle with different weight rates of flow due to the extractions. The work output of this cycle is the sum of the areas 1′-a-y-z, b-c-x-y, and d-2-w-x, or 1′-a-b-c-d-2-w-z.

Let W equal area 1-2-w-z and ΔW equal area 1′-a-b-c-d-1. Therefore the work output of the Rankine cycle is W and the work output of the regenerative cycle is $W + \Delta W$.

Thermal efficiency of a cycle is defined as Wk/Q_s. Since $Q_s = Wk + Q_r$, the thermal efficiency can be expressed as $Wk/(Wk + Q_r)$; where

Wk = net work output of cycle,
Q_s = heat supplied to cycle,
Q_r = heat rejected from cycle.

On the basis of the areas on the p-V diagram above, the thermal efficiency of the Rankine cycle is $W/(W + Q_r)$ and the thermal efficiency of the regenerative cycle is $(W + \Delta W)/[(W + \Delta W) + Q_r]$. Since Q_r is equal in both cycles, the latter thermal efficiency value is necessarily greater than the former because it differs only in the quantity ΔW, which is added to both numerator and denominator of the fraction thereby increasing its magnitude.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Report of Treasurer, 1950-1951

Ernest C. Davies
Certified Public Accountant

Evanston, Illinois
November 8, 1951

Mr. C. L. Skelley
Technical Book Department
The Macmillan Company
60 Fifth Avenue
New York 11, New York

Dear Mr. Skelley:

In accordance with your instructions we have examined the accounts and records of the American Society for Engineering Education for the year ending June 30, 1951 and submit herewith the following statements prepared therefrom:

Exhibit I—Comparative Balance Sheets
Exhibit II—Comparative Statements of Changes in Funds
Exhibit III—Comparative Statements of Income and Expense
Exhibit IV—Comparative Statements of Receipts and Disbursements
Notes to Financial Statements

In connection with the statements as of June 30, 1951, we examined and tested the accounting records, traced the receipts as recorded to deposit, checked the disbursements, counted the securities on hand, and secured direct confirmation for all funds or securities in the hands of outside parties. Our examination was made in accordance with generally accepted auditing standards and included all procedures which we considered necessary in the circumstances.

In accordance with a resolution by the Board of Directors, Furniture and Fixtures account was written down to a nominal value of $1.00 and all subsequent purchases are to be expensed.

Additional expense accounts have been added to the Statement of Income and Expense for 1951 in order to further classify the expense for the year. It is to be noted that, although some of these accounts represent expenses and incurred in prior years, others are merely a reclassification of expenses existing in 1950. Therefore, although the latter expenses were provided for in the budget, no comparison of actual and budget expenses can be made.

In our opinion these statements fairly present the position of the Society at June 30, 1951 and the results of its operation for the period then ended.

Yours truly,
ERNEST C. DAVIES
Certified Public Accountant

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEETS

	June 30, 1950	June 30, 1951
Assets		
Current Fund:		
Cash in State Bank and Trust Company	$26,280.79	$21,391.53
Petty Cash Fund	300.00	300.00
U. S. Government Bonds—Series G	30,700.00	30,700.00
	$57,280.79	$52,391.53

Life Membership Fund:		
Cash	$ 155.87	$ 183.11
U. S. Government Bonds—Series G	1,000.00	1,000.00
	$ 1,155.87	$ 1,183.11
B. J. Lamme Fund:		
Cash—Checking	$ 276.93	$ 230.46
Principal Cash in Hands of Trustee	9.00	9.00
Securities and Mortgages	5,132.73	5,132.73
	$ 5,418.66	$ 5,372.19
Accounts Receivable:		
Advertising	$ 2,503.85	$ 1,560.90
Less—Reserve for Bad Debts	315.00	——
	$ 2,188.85	$ 1,560.90
Dues	1,400.00	1,275.00
Brochures	631.20	——
Westinghouse Educational Foundation	209.73	83.91
Income Cash in Hands of B. J. Lamme Fund Trustee	121.44	121.46
	$ 4,551.22	$ 3,041.27
Inventory	$ 1.00	$ 1.00
Furniture and Fixtures (See notes to financial statements)	748.78	1.00
Total Assets	$69,156.32	$61,990.10
Liabilities and Capital		
Current Liabilities:		
Accounts Payable—Publications	$ 2,110.54	$ 16.65
Other Accruals	371.87	1,453.54
	$ 2,482.41	$ 1,470.19
Prepaid Membership Dues	$ 1,195.20	$ 1,706.78
Funds:		
Life Membership Fund	$ 1,155.87	$ 1,183.11
B. J. Lamme Fund	5,418.66	5,372.19
General Education Board	9,950.00	——
Teaching Aids Fund	——	4,362.50
	$16,524.53	$10,917.80
General Fund:		
Reserve for ECRC	$ 1,315.03	$ ——
Reserve for Special Projects	7,543.07	6,056.62
Unappropriated Surplus	40,096.08	41,838.71
	$48,954.18	$47,895.33
Total Liabilities and Net Worth	$69,156.32	$61,990.10

COMPARATIVE STATEMENT OF CHANGES IN FUNDS

	12 Months Ended June 30, 1950	12 Months Ended June 30, 1951
Life Membership Fund		
Balance at Beginning of Period	$ 1,129.70	$ 1,155.87
Add: Contribution to Fund	25.00	25.00
Interest on Fund	1.17	2.24
Balance at End of Period	$ 1,155.87	$ 1,183.11
B. J. Lamme Fund		
Balance at Beginning of Period	$ 5,477.62	$ 5,418.66
Add: Contribution to Fund	118.04	126.04
	$ 5,595.66	$ 5,544.70
Less: Award	177.00	172.51
Balance at End of Period	$ 5,418.66	$ 5,372.19
General Education Board		
Balance at Beginning of Period	$14,950.00	$ 9,950.00
Add: Refund Received from SE Section	—	3,279.02
	$14,950.00	$13,229.02
Less: Charges during the Period	5,000.00	—
Refund Made to General Education Board	—	13,229.02
Balance at End of Period	$ 9,950.00	—
Teaching Aids Fund		
Balance at Beginning of Period		—
Add: Income of Fund		$ 4,570.00
Less: Expenses of Fund		207.50
Balance at End of Period		$ 4,362.50
Balance at Beginning of Period	$41,411.11	$40,096.08
Add: Excess Income over Expense	7,543.07	—
Excess Expense over Income (See Notes to Financial Statement)	($311.07)	—
Transfer from ECRC Reserve	1,315.03	—
Transfer from Special Projects Reserve	1,486.45	2,490.41
	$48,954.18	$42,586.49
Less: Restriction of Surplus for ECRC Reserve	$ 1,315.03	—
Restriction of Surplus for Special Projects Reserve	7,543.07	—
Write off of Furniture and Fixtures	—	747.78
	$ 8.858.10	$ 747.78
Balance at End of Period	$40,096.08	$41,838.71

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	12 Months Ended June 30, 1950	12 Months Ended June 30, 1951	Budget 1951–52
Income:			
Current Dues—Individual	$38,468.18	$39,113.20	$39,000
Institutional	7,010.00	6,661.00	6,700
Sale of Publications	3,341.30	2,257.24	1,900
Advertising	10,045.16	9,401.38	9,100
Interest on Government Bonds	667.50	792.50	780
ECRC	1,031.75	1,228.06	——
Income—B. J. Lamme Fund	10.73	.02	——
Miscellaneous	39.22	863.62	——
Total Income	$60,613.84	$60,317.02	$57,480
Expense:			
Cost of Publications	$23,632.60	$24,139.43	$25,000
Salary of Secretary	5,500.00	5,500.00	5,500
Salary of Office Secretaries	2,070.00	4,970.00	5,640
Clerical Salaries	3,352.10	548.44	700
Retirement Emeritus	1,360.00	1,360.00	1,360
Travel-Secretary's Office	989.94	1,007.73	950
Postage, Telephone and Telegraph	1,595.50	1,416.98	1,600
Supplies, Expense, Sundry Prtg.	2,052.68	2,895.55	2,700
Dues—Am. Council on Education	100.00	100.00	100
Contribution ECPD	500.00	500.00	500
Officers Traveling Expense	1,510.91	1,694.64	2,000
Annual Meeting Expense	2,737.84	2,016.53	2,700
Expenses ECAC	733.44	1,630.66	2,200
Expenses ECRC	4,334.18	8,379.54	4,350
Committees and Conferences	609.95	1,153.57	1,300
President's Expense	——	460.87	500
Bonding, Auditor's and Other Society Fees	——	486.28	325
Office Expense	——	80.27	——
Miscellaneous	——	75.31	——
Special Projects Expense	1,991.63	——	——
Purchase of Typewriters	——	291.45	——
N.Y. Times Reprint	——	615.71	——
Committee on Improvement in Teaching	——	397.42	——
Contribution EJC	——	407.71	——
Additional Contribution ECPD	——	500.00	——
Total Expense	$53,070.77	$60,628.09	$57,425
Excess of Income over Expense	$ 7,543.07		
Excess of Expense over Income		$ 311.07	
Transfer from reserves to cover ECRC loss (see notes to statements)		$ 2,801.48	
Balance to Surplus		$ 2,490.41	

COMPARATIVE STATEMENT OF RECEIPTS AND DISBURSEMENTS

	12 Months Ended June 30, 1950	12 Months Ended June 30, 1951
Balance at Beginning of Period	$39,201.86	$26,280.79
Receipts:		
Current Dues—Individual	$35,435.18	$36,600.00
Institutional	7,010.00	6,586.00
Back Dues	1,733.25	1,518.00
Dues in Advance	1,195.20	1,706.78
Sale of Publications	2,710.10	2,888.44
Advertising	9,396.31	10,029.33
Interest on Bonds	667.50	792.50
ECRC	1,031.75	1,228.06
Westinghouse Educational Foundation	222.29	250.00
Lamme Fund Income	——	——
Refund from SE Section to Close Fund	——	3,279.02
Teaching Aids Income	——	4,570.00
Miscellaneous	39.22	863.62
Total Receipts	$59,440.80	$70,311.75
Disbursements:		
Cost of Publications	$23,122.06	$26,233.32
Administrative Salaries	10,922.10	11,018.44
Retirement Emeritus	1,360.00	1,360.00
Travel—Secretary's Office	989.94	1,007.73
Postage, Telephone and Telegraph	1,656,67	1,325.32
Supplies and Sundry Printing	2,052.68	2,809.05
Dues—American Council on Education	100.00	100.00
Contribution ECPD	500.00	500.00
Officers Traveling Expense	1,510.91	1,644.04
Annual Meeting Expense	2,422.36	1,491.35
Expenses ECAC	733.44	1,618.13
Expenses ECRC	4,334.18	8,038.37
Committees and Conferences	598.25	1,132.79
Westinghouse Award	322.44	124.18
Expense—Carnegie Survey	4,745.21	——
Award—General Education Board	5,000.00	——
Purchase of Government Bonds	10,000.00	——
President's Expense	——	442.62
Teaching Aids	——	207.50
Bonding, Auditor's and Other Society Fees	——	486.28
Office Expense	——	80.27
Miscellaneous	——	75.31
Special Projects		
Purchase of Typewriters	——	356.45
NY Times Reprint	——	615.71
Committee on Improvement of Teaching	1,991.63	397.42
Contribution EJC	——	407.71
Additional Contribution ECPD	——	500.00
Refund to General Education Board	——	13,229.02
Total Disbursements	$72,361.87	$75,201.01
Balance at End of Period	$26,280.79	$21,391.53

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
NOTES TO FINANCIAL STATEMENTS

By resolution of the Board of Directors furniture and fixtures were written down to a nominal value, and in conformity with this policy new typewriters purchased were charged against the current year's operations.

It was further resolved by the Board of Directors that a transfer should be made from the appropriated surplus to provide for the excess of ECRC expenses over the sum of ECRC income and the expenditures allowed by the Society budget. The computation of the transfer was made as follows:

ECRC Income	$1,228.06	
Budgeted Expenditures	4,350.00	
	$5,578.06	
ECRC Expense	8,379.54	
Net Loss		$2,801.48
To be provided for:		
By transfer from ECRC Reserve	$1,315.03	
By transfer from Special Project Reserve	1,486.45	
		$2,801.48

ECRC expenses exceeded anticipations as a result of heavy publication costs. ECRC would not have operated at a loss if the inventory of the unsold publications had been carried on the balance sheet. (This inventory was approximately $3000 at cost on balance sheet date.) However, in conformity with Society policy of carrying only the most liquid assets on the balance sheet, the inventory of unsold publications was excluded, and the above policy was adopted.

Respectfully submitted,

CHARLES L. SKELLEY,
Treasurer

Mid-Winter Meetings

The Cooperative Division of the ASEE held its third Annual Mid-Winter meeting at Northwestern University, November 8, 9, and 10. The program was planned to be a part of the Technological Institute's program in the Centennial celebration of Northwestern University this year.

A conference of the Division of Relations With Industry will be held at the Massachusetts Institute of Technology on February 2, 1952. The theme of the conference will be "The Student as an Individual." A meeting of the Advisory Committee of the Division will be held on Friday, February 1, 1952, at 9:30 A.M. The first draft of the papers to be presented at the June meeting will be discussed.

The Mid-Winter meeting of the Engineering Drawing Division will be held at three New York universities—The Cooper Union, U. S. Military Academy at West Point, and Columbia University on January 23, 24 and 25, 1952. The complete program was published in the November issue of the JOURNAL OF ENGINEERING EDUCATION.

THE T-SQUARE PAGE

Officers
C. H. SPRINGER, *Chairman*
R. T. NORTHRUP
T. T. AAKHUS
C. J. VIERCK
J. S. RISING
H. E. GRANT
R. S. PAFFENBARGER

DEVOTED TO THE INTERESTS
OF ENGINEERING DRAWING

B. L. WELLMAN, *Editor*
Worcester Polytechnic Institute

Officers
J. GERARDI
J. G. MCGUIRE
W. E. STREET
C. E. ROWE
H. C. SPENCER
W. J. LUZADDER

What Happened at East Lansing?

For six very busy days 177 engineers and teachers talked and listened, debated and relaxed, in the lecture room of Olds Hall and in the luxurious lounges of Shaw Hall. The subject was engineering drawing, the time was June, and the place was the beautiful campus of Michigan State College. With such a matchless combination it is not surprising that the third Summer School for Teachers of Engineering Drawing was a complete success.

Our gracious host provided comfortable rooms and excellent meals in their new and very modern Shaw Residence Hall, while the weather man very reasonably insisted upon only one rainy day. The sessions in Olds Hall were intensive and stimulating, and were conducted with engineering precision. Sunday conveniently interrupted the sessions to allow members to drive to Detroit, Greenfield Village and Edison Institute, or to just relax and talk more shop.

The theme of the Summer School was: Improving Our Status as Engineering Drawing Teachers. A complete list of the papers to be presented was published in the May, 1951, issue of the Journal of Engineering Drawing. Space does not permit a discussion of each of the 23 papers presented at the meeting, nor of the many questions and comments that buffeted the panels of "experts" (a term they all modestly rejected) at the end of each session. Needless to say, the panel members acquitted themselves admirably, and their comments and summations contributed much of value to the sessions. It was the concensus of many members that these panel discussions ought to be continued at future meetings.

It was the observation of your editor that the questions most frequently asked and discussed were: 1) is there an increasing pressure to further reduce the time allotted to drawing? 2) are integrated drawing courses pedagogically sound and more efficient of time? 3) how can we convince the administrations that descriptive geometry is a vital part of an engineer's education? 4) what kind of visual aids can best be adapted to the teaching of drawing? 5) what can we do to promote more work in advanced graphics? 6) is the master bow professional type set the best for student use? 7) what to do with students who have had drawing in high school?

Although the above topics were very popular and much debated, the solutions proposed were many and varied. Much more remains to be said, and your editor will welcome and publish on this page any further discussion. Take any side of the issue, but write it down and send it in. One man's opinion often proves to be the right one.

At the Annual Business Meeting the results of the election were announced and the newly elected officers for the coming

year are:

Chairman: C. H. Springer
Secretary: R. T. Northrup
Member Ex. Com.: J. S. Rising
Ed. T-Square Page: B. L. Wellman
Adv. Manager: C. J. Vierck

The amendment to the Articles of Procedure to create the new office of Vice-chairman was unanimously adopted by the membership. This amendment was announced in the May issue of the *Journal of Engineering Drawing*. Following the adoption, Dean Jasper Gerardi was nominated and elected to the new office.

Chairman-elect Springer then announced that "in view of the great concern felt by members of the Drawing Division about the continued and progressive squeeze being placed on all drawing departments for time, that the Policy Committee of the division has been instructed to formulate a policy that could be implemented by the entire division to combat this tendency."

Chairman Paffenbarger reported that the Mid-Winter Meeting will be held in New York on January 23, 24 and 25, 1952. The program for this meeting will be announced on this page in an early issue. It was also announced that the Mid-Winter Meeting for 1953 will be held at the University of Nebraska at Lincoln, Nebraska.

Summer Schools

The Executive Board of the ASEE has authorized sponsorship of summer schools proposed by the Electrical Engineering Division and the English Division. Both summer schools will be held at Dartmouth preceding the Annual Meeting. A summer school on Sanitary Engineering has been proposed by the Civil Engineering Division.

The General Electric Company has proposed a summer school program on methods of instruction which would familiarize educators with some of the novel methods of instruction used in the GE Company's post-graduate program. The Executive Board authorized ASEE endorsement of this summer school program.

New Members

BACH, GEORGE L., Dean, Graduate School of Industrial Administration, Carnegie Institute of Technology, Pittsburgh, Pa. W. N. Jones, R. B. Teare.

BARTHOLOMEW, EDWARD L., JR., Associate Professor of Mechanical Engineering, University of Connecticut, Storrs, Conn. C. H. Coogan, Jr., F. L. Castleman, Jr.

BOWMAN, LEE, Head, Architectural and Photographic Depts., Franklin Technical Institute, Boston, Mass. B. K. Thorogood, R. G. Adams.

CARPENTER, HOWARD J., Assistant Professor of Mechanical Engineering, University of Vermont, Burlington, Vt. A. F. Tuthill, J. A. Bullard.

CASEMAN, AUSTIN B., Instructor in Civil Engineering, State College of Washington, Pullman, Wash. E. G. Ericson, L. B. Almy.

CRIM, ELMER B., Director, Co-operative Education, Stetson University, LeLand, Fla. S. C. Hollister, A. B. Bronwell.

DECKER, J. J., Office Manager, Advertising and Sales Prom., American Radiator and Standard Sanitary Corp., Pittsburgh, Pa. G. D. Lobingier, G. L. Scott.

DUCHACEK, HOWARD, Assistant Professor of Mechanical Engineering, University of Vermont, Burlington, Vt. A. F. Tuthill, J. A. Bullard.

FLICK, CARL, JR., Research Fellow, Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. C. C. Whipple, J. W. Hostetter.

GOEHRING, HENRY G., Placement Director, College of Engineering, University of Wisconsin, Madison, Wis. R. A. Ragatz, M. O. Withey.

GREENE, JAMES H., Assistant Professor of Industrial Engineering, Purdue University, Lafayette, Indiana. R. W. Lindley, O. D. Lascoe.

HAMMOND, ALEXANDER F., Instructor in Drawing and Designing, Clemson College, Clemson, S. C. J. E. Shigley, S. R. Rhodes.

HEINLEIN, DAVID M., Head, Science Dept., Rutgers Preparatory School, New Brunswick, N. J. E. C. Easton, M. T. Ayers.

HUDELSON, GEORGE D., Assistant Professor of Mechanical Engineering, Ohio State University, Columbus, Ohio. S. R. Beitler, A. I. Brown.

JENKS, JOHN F., Assistant Professor, Technical Extension Division, Purdue University, Indianapolis, Ind. E. C. Susat, A. W. Collins.

JONES, THOMAS F., JR., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, K. L. Wildes.

KAUZLARICH, JAMES, Assistant, Graphics Dept., Columbia University, New York, N. Y. A. P. Boehmer, A. B. Cambel.

LESLIE, PHILIP, Assistant in Chemistry Library, University of Illinois, Urbana, Ill. W. C. Huntington, S. H. Pierce.

LUKER, JAMES A., Assistant Professor of Chemical Engineering, University of Denver, Denver, Colo. D. C. Davis, Jr., T. O. Reyhner.

MAECHLER, HUGO C., Assistant Professor of Drawing, University of Wisconsin Extension, Milwaukee, Wis. J. G. Van Vleet, W. M. Christman, Jr.

MARSHALL, GILBERT A., Instructor in Mechanical Engineering, University of Vermont, Burlington, Vt. A. F. Tuthill, E. R. McKee.

MASON, MARTIN A., Dean of Engineering, George Washington University, Washington, D. C. C. H. Walther, J. S. Antel.

MATCHETT, GERALD J., Associate Professor of Business and Economics, Illinois Institute of Technology, Chicago, Ill. P. Davis, E. R. Whitehead.

MCAMIS, J. C., JR., Assistant Professor of Mechanical Engineering, University of Tennessee, Knoxville, Tenn. R. C. Robertson, J. D. Maloney.

McCORMICK, JAMES P., Assistant Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y. R. A. Record, A. R. Powers.

McDOWELL, ELMER H., Instructor in Industrial Drafting, Kansas Technical Institute, Topeka, Kans. G. R. Cotton, H. L. Livas.

MIRSKY, ARON L., Assistant Professor of Civil Engineering, University of Connecticut, Storrs, Conn. K. C. Tippy, G. Timoshenko.

MONTGOMERY, SIGMUND J., Associate in Industrial Engineering, Columbia University, New York, N. Y. S. C. Hollister, A. B. Bronwell.

NICHOLS, KENNETH V., Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. H. R. Peterson, T. J. Higgins.

NIELSEN, HAROLD, Assistant Professor of Mechanical Engineering, University of Dayton, Dayton, Ohio. A. J. Westbrock, A. R. Weber.

OXFORD, CHARLES W., Assistant Professor of Chemical Engineering, University of Arkansas, Fayetteville, Ark. W. B. Stiles, N. H. Barnette.

REED, GEORGE W., Assistant Professor of Electrical Engineering, Clarkson College of Technology, Potsdam, N. Y. A. R. Powers, A. B. Bronwell.

RITCHIE, MARGUERITE, Engineering Librarian, University of Maryland, College Park, Md. R. B. Allen, J. E. Younger.

SCOTTRON, VICTOR E., Associate Professor of Civil Engineering, University of Connecticut, Storrs, Conn. F. L. Castleman, Jr., K. C. Tippy.

SIDLE, ROBERT G., Chairman of Mechanical Engineering, University of Vermont, Burlington, Vt. C. M. Thomson, J. A. Bullard.

SKILES, JAMES J., Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. T. J. Higgins, H. A. Peterson.

SMITH, CLYDE P., Instructor of Manufacturing Processes, General Engineering Dept., Purdue University, Lafayette, Ind. O. D. Lascoe, H. A. Bolz.

SMITH, GUSTAVUS E., Assistant Professor of Electrical Engineering, University of Kentucky, Lexington, Ky. D. V. Terrell, A. B. Bronwell.

STREET, DONALD T., Associate Professor of Engineering, University of Rochester, Rochester, N. Y. R. F. Eisenberg, C. L. Rickard.

TATE, VERNON D., Director of Libraries, Massachusetts Institute of Technology, Cambridge, Mass. S. C. Hollister, A. B. Bronwell.

WEINBERG, PHILIP, Instructor in Electrical Engineering, University of New Mexico, Albuquerque, N. M. W. G. Hoover, M. E. Van Valkenburg.

WELLINGTON, CHARLES B., Extension Lecturer in Mechanical Engineering, University of New Hampshire, Durham, N. H. E. H. Stolworthy, E. T. Donovan.

WENDT, ROBERT H., Vice-President and General Manager, Globe Corporation, Aircraft Division, Lockport, Ill. K. L. Burroughs, A. Stott.

YATES, EDWIN L., Director of College and University Relations, General Motors Corporation, Detroit, Mich. J. C. McElhany, K. A. Meade.

214 new members this year

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Report of Committee on Adequacy and Standards of Engineering Education

By S. C. HOLLISTER, *Chairman*, C. S. CROUSE, L. F. GRANT, and M. D. HOOVEN

Introduction

The aim of this report is to present at least in spirit the impressions of your committee concerning the adequacy of present-day engineering education and observations relating to what it estimates to be the standards employed by the engineering schools. Any attempt to appraise the present position of engineering education is destined to cause a certain amount of misunderstandings, due largely to the attitude of the reader at the time, and the impression the words convey in the climate provided by that attitude. Specific statements are often too limiting when taken literally, and generalizations are often too vague. An endeavor has been made, however, to present for consideration the committee's views on the present situation with the hope that, though brief and at times over-simplified and specific, the main observations will be accepted in their intended perspective.

Growth of Engineering Curricula

Engineering education in America was not developed after a preconceived plan. It evolved in parallel with the needs of a growing country, a country engaged in the development of a vast industrialization. From the first it filled a practical need, and its design emanated largely from an evaluation of the professional requirements.

There were only a half dozen schools of substantial merit by 1866. While the concept of engineering was the application of science to useful purposes, the educational program was heavily charged with the art of engineering practice. The better curricula had their roots in scientific studies. At that time, and for a generation to follow, a majority of practicing engineers were not engineering college graduates; they were men who through experience, observation and study, developed themselves to the point where they could cope with the technical problems of their time. Books began to appear and, with the development of laboratories for the teaching of principles (which, by the way, had been by 1870 in operation for 15 years in the Chemistry Department at the University of Michigan), gave strength to the program of the colleges in systematization of technical knowledge.

With the passage of the Morrill Act in 1862 the means and urge to found in each state a program in the mechanic arts for the aid of manufacturers were at hand. From 1870 to 1896 there was rapid expansion of the number of schools to 110 and the gradual formulation of the curriculum. By 1910 the forms of curricula in the older branches of the profession were pretty well standardized as to pattern. No elevating influences appeared to be at work on other than the newer curricula, such as chemical and metallurgical enginering, until the first World War.

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Report of Committee on Adequacy and Standards of Engineering Education

By S. C. HOLLISTER, *Chairman*, C. S. CROUSE, L. F. GRANT, and M. D. HOOVEN

Introduction

The aim of this report is to present at least in spirit the impressions of your committee concerning the adequacy of present-day engineering education and observations relating to what it estimates to be the standards employed by the engineering schools. Any attempt to appraise the present position of engineering education is destined to cause a certain amount of misunderstandings, due largely to the attitude of the reader at the time, and the impression the words convey in the climate provided by that attitude. Specific statements are often too limiting when taken literally, and generalizations are often too vague. An endeavor has been made, however, to present for consideration the committee's views on the present situation with the hope that, though brief and at times over-simplified and specific, the main observations will be accepted in their intended perspective.

Growth of Engineering Curricula

Engineering education in America was not developed after a preconceived plan. It evolved in parallel with the needs of a growing country, a country engaged in the development of a vast industrialization. From the first it filled a practical need, and its design emanated largely from an evaluation of the professional requirements.

There were only a half dozen schools of substantial merit by 1866. While the concept of engineering was the application of science to useful purposes, the educational program was heavily charged with the art of engineering practice. The better curricula had their roots in scientific studies. At that time, and for a generation to follow, a majority of practicing engineers were not engineering college graduates; they were men who through experience, observation and study, developed themselves to the point where they could cope with the technical problems of their time. Books began to appear and, with the development of laboratories for the teaching of principles (which, by the way, had been by 1870 in operation for 15 years in the Chemistry Department at the University of Michigan), gave strength to the program of the colleges in systematization of technical knowledge.

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Between the two World Wars the engineering schools developed programs in electronics. Although these and the newer pre-war programs were patterned after the "standard" form of curriculum, they nevertheless introduced new elements of strength in the increase of basic and applied science; and it was soon noticeable that they possessed more vitality and

potential than the older programs. Yet most schools did little or nothing about these older curricula. Instead, most colleges of engineering were preoccupied with the development of various offerings to cover students interested in the fringe areas: those who would be contiguous to, but not really a part of, engineering itself. While these programs served a useful need, their inclusion in one guise or other as *engineering* programs was a clear departure from the earlier concepts of professional training.

During the entire period from the earliest days to the second World War, there was not an established position for the technical school offering a program that would be post-high school, but with more emphasis on high-grade craftsmanship training than on professional education. Many of the earliest schools of this type gradually expanded to four-year programs. A few, having a clear view of the need and great importance of such training, have held to their convictions and have developed strong programs with notable results.

Critical Evaluation of Factors in Engineering College Development

As one examines the history of the growth of engineering colleges and their development, certain features thereof are especially evident. The very rapid expansion in both number and size of schools left little choice than to imitate the more successful. Not so obvious was an underlying situation that many of the new schools had only a dim concept of their objective in service to the profession. There was at work in the same setting the notion of spreading higher education for all, a factor that is restrictive of high standards. As schools grow, the pressure for staff expansion led to recruiting by the simple process of keeping on recent graduates, and then allowing them to do their graduate work, if any, while teaching. In this way, there was a subtle influence of continuity of curriculum with little urge for re-evaluation or vitality of concept of objectives. A standard pattern was achieved, not so much by deliberative process as by a sort of combination of gravitation and inertia.

Coupled with these influences was the circumstance of ever-pressing financial problems in young and growing schools, and the consequent limit on salary scales. Not a few administrators found themselves unable to pay salaries that would command talent already developed, and in some cases they could do little more than employ something less than the top of the currently graduating class—"temporarily." The deadening effect of obsolescence upon laboratory equipment, some of it hard-won after years of waiting and planning, had its part in gradual "standardization" through the lack of means to preserve a dynamic program.

Over the years, the number of practicing engineers without engineering college education was gradually diminishing. This was due in part to the availability of engineering schools, and to an increasing extent to the complicated nature of the engineering function. Between the World Wars, with the introduction in many schools of programs with greatly reduced scientific and technical content, yet calling the output "engineers," there arose increasing confusion as to what constituted engineering and what characterized engineers. Accountants, for example, and graduates of business courses, and others, who had enterprise to pose as consultants on managerial matters, called themselves management or industrial engineers. Graduates of such courses could perform but elementary engineering functions. There can be no question that these courses of reduced technical content were an aid to certain persons; the serious doubt was whether they should have been considered *engineering* courses.

From the earliest days the program of engineering education was limited to four years, in parallel with the usual undergraduate college program. A very few schools added one or two years, with an additional degree. During the period of development and growth, the medical, legal and architectural professions have

extended their length of program to meet their particular objectives. It is significant that these developments had no effect upon the engineering professional program and that in consequence, with conspicuously few exceptions, the engineering curricula have remained four years in length, beginning immediately after high school.

Meantime, the fields of sciences, without exception, have been obliged to extend their programs through the addition of graduate work. Today no scientist is considered adequately trained without the doctor's degree. Whether graduate work is an appropriate program for the professional engineer is one of the questions dealt with by your committee.

Probably the most significant single characteristic of the engineering educational field is that it has no generally accepted professional objective as a goal for the educational program. There is general agreement respecting the form of the curriculum. It is difficult to detect differences in programs between schools simply by comparison of curricula. The major differences lie in the depth of instruction and in the objective of each institution in respect of the professional outlook to be achieved. There exists today a spectrum of objectives ranging from highly professional programs supported by strong science backgrounds to vocational programs in which only a moderate amount of science is included.

It is possible to divide the subjects included in any engineering curriculum into five groups, as follows:

1. Basic science (mathematics, physics, chemistry, biology).

2. Applied science (mechanics, thermodynamics, fluid mechanics, geology, circuit theory, properties of engineering materials, etc.).

3. Applied engineering (for example, internal combustion engines, structures, machine design, industrial electronics, foundry technology, plant design, etc.).

4. Adminstrative and managerial (cost control, industrial organization, labor relations, etc.).

5. General (liberal courses, to provide a general educational background). Curricula may vary in the emphasis placed upon group, and in the extent of dominance of one group over the others.

Historically, applied engineering courses dominated the curriculum in the early years. Gradually the pattern of basic science courses was evolved and generally included. Shop courses were reduced to a minimum.. From 1885 until the first World War, mathematics was stabilized in the older curricula, terminating with the calculus. Since then only a few schools have carried the subject further in civil, chemical, mining, and mechanical engineering, while many schools have required additional mathematics in electrical engineering. Except in chemical engineering, and in some cases of mining engineering, the amount of chemistry required has been limited to general inorganic chemistry.

The time requirement in physics has remained nearly constant in most curricula since about 1885. Generally, the classical approach to physics instruction has been followed. The depth has varied with the amount of mathematics available at each stage. The calculus, while standard in all curricula, is not employed to the same degree in physics. In civil and mechanical engineering the amount of physics is limited to one year in most schools; and in many the same limit is found in electrical and chemical engineering. Generally, however, the approach from the point of view of atomic and molecular structure is needed but wanting.

The time devoted to mechanics is similar in nearly all schools. The variation in effectiveness of the course is not due to allotted time so much as to the depth of instruction. For many years it was the custom to minimize the use of the calculus in this subject. The development of stronger texts over the last two decades has greatly improved the effectiveness of the instruction; however, there is still much variation in depth of the requirements placed on the student. There may be said to be a definite upswing in the

quality of instruction in mechanics, although this it not believed to be general. In mechanical engineering, for example, vibrations and their consequences are treated in only a few schools. In fact, in civil engineering dynamics is regarded as being unnecessary, yet fatigue is becoming more important in structural design.

Hydraulics used to be taught from the empirical standpoint. Between the two wars there was pressure, emanating from the aeronautics field, for instruction in fluid mechanics. Some schools dealt sincerely with this proposed change; but many others simply changed the course name from hydraulics to fluid mechanics.

While in chemical engineering thermodynamics has been taught with regard to interaction between the thermal and chemical circumstances involved, there has been little attention given to such matters in mechanical engineering. Today, a chemical engineer is not infrequently better trained for fundamenal work in heat power than the mechanical engineer, in whose field heat power lies.

During the past several decades the instruction relating to engineering materials has developed into a program reciting a general discussion of their manufacture, and their mechanical properties as revealed by standard acceptance tests. The metallurgical aspects are lightly touched upon if at all. Instances can be found of the absence of a course in materials in electrical engineering, while in other cases in the same field students get the notion that such instruction together with the mechanics of materials is largely unnecessary for an electrical engineer, especially in communications.

Factors of Major Significance in Curriculum Design

Many perplexing problems stem from the fact that the engineering college, in preparing students for professional work that will reach maximum culmination twenty or more years hence, must evaluate hazily discernible future events. It certainly appears desirable that a major stress be placed upon those elements of the curriculum that will give the most continuous and lasting support to the graduate's professional life. Apart from the teaching of the professional attitude toward engineering and the instilling of the engineering and scientific method of attack upon problems, there are certain specific features of the curriculum that can be accepted as most essential.

The first of these has to do with courses least likely to obsolesce. While it is necessary to give a certain amount of instruction relating to the present state of the art, it is certain that the present state will change, and hence that time given to such courses is not time devoted to a subject of sustaining value. Sifting back through the curriculum, it seems clear that instruction in the basic sciences, if taught in a manner such that knowledge of them makes available working tools, contributes the most sustaining part of the curriculum. Among these basic sciences, the greatest potential for future development in science and technology is to be found in mathematics. An engineer with a good knowledge of mathematics is in a position to read with understanding and profit in physics and chemistry. Likewise, as his interest and need may expand, he may read further in the applied sciences, such as mechanics, elastic stability, advanced thermodynamics or fluid mechanics. Similarly, new applications of sciences to engineering situations may be understood and assimilated. Thus, mathematics not only becomes the support of the group of courses that will obsolesce least; it becomes the means of further technical growth as befits the graduate's interest and need. Building into the program in this and other means for further technical self-development of the individual after graduation is the second most important feature of a well-designed curriculum.

The third feature that impresses your committee as of ranking importance has to do with the way in which the applied courses are related to those in basic and applied science. Two distinct approaches

are discernible in present practices: one utilizes the engineering situations provided in the applied courses to illustrate the manner of employing the sciences in engineering work, while the other makes the applied courses the goal of the curriculum with the minimum of application of the sciences. The former builds into the student a power of analysis and resolution in engineering situations that permits a wide range of application. The latter tends toward the achievement of a series of skills intended to equip the student for specific jobs immediately upon, and soon after, graduation. The first is professional preparation, the second vocational training. What is involved is not alone the way in which individual courses are presented; it especially relates to the prevailing concept of the function of the whole curriculum.

Following the concept that the differentiating characteristic of the engineering function is the ability to utilize the sciences for the creative process of design and development of useful apparatus, structures or other works, the program should aim at the development and expansion of the imaginative process of creative thought. Engineering educational processes are most commonly of the problem type, requiring but a single answer, with no latitude for judgement, and no imaginativeness beyond the visualization of the circumstance of the problem. Programs in architecture far surpass those in engineering in this respect. We tend toward producing a literal-mindedness that is not compatible with creative imagination.

The foregoing discussion has been in broad terms. It is believed that quantitative specifications for engineering curricula are not adequate as guides to curriculum planning because they tend toward regimentation, toward fixation, and toward eventual stagnation of awareness of the professional needs. The content in each of the five categories enumerated above must be determined in terms of the need of the graduate two or three decades ahead, not in specific detail but in sound skeletal preparation, with most of the details to be filled in through further study and acquisition of experience in the field. The skeletal program must be strong and of sufficient stature to support and sustain the growing professional career.

Engineering is both a science and an art. A balance between both is desirable. The tendency has been to emphasize the art unduly. The "engineering approach" can be presented in the manner in which science is brought to bear on an engineering situation. Much of the art can better be acquired in the field. Industry is coming quite generally to recognize this arrangement as desirable for its needs.

Suggested Program

The quality of engineering curricula varies over a wide range, from highly developed professional programs to those having a predominantly vocational content. The foregoing discussion relates especially to the middle and lower portion of the range. Accrediting procedures relate almost entirely to the minimum standards, and tend to breed complacency among those schools that just barely satisfy such a standard. While accrediting must be maintained as a part of the licensing procedure, it cannot be expected that accrediting of itself will achieve the improvement of schools that satisfy the minimum requirements—unless two or more classes of schools were established and accrediting set up for each class. Your committee believes that such a scheme would neither be welcome nor desirable. Rather it believes that the engineering educational field has a great opportunity to study itself, with the object of finding ways at all levels to improve its service to the profession.

One way to make such a study is to set up an agency that would study and report its findings, as was done by the Society for the Promotion of Engineering Education in the Twenties, under the late W. E.

Wickenden.[1] Such a procedure has the effect of isolating the study, and removing it from the schools themselves. The conclusions of Wickenden, written in 1929, are to be found in Appendix I of this report; and your committee is struck with the potency of the statement to today's situation, and the extent of the failure of the schools to implement much of the recommendations. Other statements, appearing since the Wickenden Report and bearing upon the same subject, are given in the remaining appendices.[2] From these it seems clear to your committee that what is now needed is active study and self-appraisal by the schools themselves, looking toward implementation of recommendations already made.

In some quarters the suggestion has been made that an overlay of graduate work is the answer to a need for stronger science content in the curriculum, and to a higher total level of achievement. Your committee believes that the basic program in engineering leading to the first degree in the field should be of a quality to suffice for the professional need of perhaps eighty percent of the graduates, and that truly graduate work should be reserved for the remaining few having special competence. The responsibility for support of the profession, it is believed, must rest chiefly upon the adequacy of the undergraduate program.

The great pressure upon the engineering schools to provide general education in addition to an increased scientific and technical training brings them constantly face to face with the limitation in time imposed by the conventional curriculum. It is perhaps time that this problem was approached in terms of total need; and then the time required to achieve this need be measured beginning with the preparation now available from the secondary schools. For many years the approach has been to see what can be given within the four-year framework, with the result of over-crowding the program and with a general shifting first in one direction and then another without total gain in achievement. Other professions have had to face this issue. If engineering maintains professional stature, it will have to organize accordingly. Some have suggested a pre-engineering period in which the high school preparation may, if necessary, be augmented to a desired level before beginning engineering study.

There has been some discussion of the list of degrees granted in engineering. There is a gradual tendency to drop the professional degrees of C.E., M.E., etc., awarded after a suitable interval of practical experience and the submission of an acceptable thesis. If the professional degrees became generally available for work in course, they could then be used to designate the longer programs that are now under way, whether they be one-degree or two-degree programs.

Finally, it becomes clear that there is going to be a shortage of engineers for many years to come. At such a time, in the national interest, it is of paramount importance that the best possible education in engineering be provided by our schools. Each man is going to be called upon to cover a greater range than heretofore, if the engineering needs are to be met. Every school should devote itself to ways of substantial improvement of its program, to the end that its graduates will meet the responsibilities being placed upon them.

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[1] "The American Scene," by W. E. Wickenden, Director, Investigation of Engineering Education, *SPEE*, Vol. I (1929), p. 1000.

[2] (*a*) "Engineering and Social Progress," by Karl T. Compton, *Proceedings, SPEE*, Vol. XLVII (1939), p. 8.

(*b*) "Atomic Engineering?," by Theodore von Kármán, *Mechanical Engineering*, October, 1945, p. 672.

(*c*) "Tomorrow's Engineers," by J. R. Van Pelt, Excerpt from *Proceedings, ASEE*, Vol. 55 (1948), p. 168.

(*d*) "Present-day Engineering and Applied Science"; Report of Panel on the McKay Bequest, Harvard University (1950), p. 7.

Cooperative Relationships Between Engineering Colleges and Secondary Schools

By GEORGE K. DREHER

Executive Director of the Foundry Educational Foundation

A Starting Point

A typical engineering approach requires that we first identify the problem and then gather the facts before a solution can be sought. In secondary school—engineering college cooperation, the same formula can apply. This paper is presented as one case. It is an attempt to identify a few of the road blocks and facts which prevent the full alignment of educational forces toward the solution of the shortage of engineering graduates.

The opportunity to tackle this secondary school angle came about as a friendly criticism of engineering college practices by representatives of the Cleveland High School system. This criticism was promptly answered by Dean S. C. Hollister (President of the American Society for Engineering Education) during a special visit to Cleveland and in a meeting attended by many high school principals and representatives of the Cleveland Guidance and Placement Counselling service under the Staff Direction of Miss Mildred Hickman.

This, then, is to be an analysis of the situation in Cleveland. Many of these points probably apply in all major secondary school systems. The facts in this history lead to certain recommendations which we will cover a bit later.

The Cleveland High Schools

First of all let us just take a brief look at the Cleveland secondary school establishment. Of direct interest to engineers is the fact that the male graduating classes beginning in 1922 when 997 young men completed their high school work, did show constant increases up to a peak in 1939 of 3853. Since that time, with the exception of one odd year, this number has steadily dropped to 1897 in 1951. During the years 1945 through June of 1951, inclusive, some 4878 boys enrolled in Colleges out of a total of 16,099 male graduates. This represents 30.3% of the male high school population. A good share of this total was due to the fact that during this period 2907 of these graduates were GI's who qualified for high school diplomas and who thereafter had educational rights under the GI program.

1271 of this graduating group entered engineering study. This represents 7.85% of the male graduating class. Fenn College and Case Institute of Technology, with Ohio State University a good third, received the major portion of this group. Against the College entrants this represented 26% for engineering (a very high proportion over the seven year period). In this summary one high school, East Technical, sent 20% of its graduates (¾'s of its College entrants) into engineering college. A good share of this is due to the guidance effected by East Technical's principal, Mr. Bernard Taylor. His curriculum has gradually evolved so as to permit organized preparation for engineering study.

The engineering college percentage for the 12 eligible schools varies from a low of .19% to the 20% just mentioned. The following chart shows present trends.

FIVE HIGH SCHOOLS SHOWING HIGHEST ENGINEERING INTEREST (COLLINWOOD, EAST HIGH, EAST TECHNICAL, MARSHALL, WEST HIGH). REPRESENTING 83% OF ENGINEERING COLLEGE ENTRANTS FROM THE ENTIRE TWELVE CLEVELAND HIGH SCHOOLS

Subject	1945–1951 (Incl.) Averages	1951 Alone	
Average Male Graduates	987	786	(80% of average)
Average Males to College	321	250	(78% of average)
Average Males to Engineering College	151	82	(54% of average)
Per Cent of Engineering/High School Graduates	15.3%	10.4%	

The Cleveland school system is proud of its student mortality record as compared to national averages. They state that the national mortality record of high school students is in the neighborhood of 50%. In Cleveland it is a good 10% higher being 55% for the boys and 65% for the girls. There are several conditions aiding this high school mortality at the present time. Some of the defense plants are offering high wages for men without any training. In Cleveland, for the past many years, the building trades have been especially lucrative with the average carpenter, plumber, brick mason and electrician earning far in excess of the published averages for engineering, or for that matter for college students.

The industrial nature of the city of Cleveland, itself, makes its population predominantly of industrial workers. While many families wish that a College education might be arranged for their children, the fact remains that in most cases the inspiration and caliber of family training is not such as to lead a young man along the rigorous mental path necessary for successful college careers. Another factor is the lack of finances. Military service is a deterrent and we believe that many young men join directly from high school through purely emotional factors and with the hope that the much advertised education offered in the various branches will somehow prepare them for civilian life later on.

I might add, at this point, that engineering is not the only field suffering under the present circumstances. Young girls with a very slight amount of typing and shorthand instruction are being urged to leave school by Cleveland industry and take positions in their offices and we might add, at lucrative salary levels from $200.00 and up.

In its guidance and placement activity the Cleveland school system, of course, does have some policies. Prominent among these is the one which states that they will not recruit students for any specific field of study. They will guide the interests and wishes of students and their parents. At the same time, however, they indicate a willingness to cooperate with universities and other agencies attempting to sell their school or their field of endeavor. From our viewpoint, this includes the engineering colleges and the Engineering Societies as represented by the Cleveland Technical Societies Council. The Cleveland schools seek to avoid the exploitation of their students by any group which includes the professions.

Road Blocks

In addition to the above policies there is a certain reluctance to push engineering. There are several listed reasons for this, but prominent among them must be placed the fact that there are very few engineers in secondary education and that practically all of the Counseling work is accomplished from the viewpoint of the schools of Education and Liberal Arts. The following points are more specific, however, and we will list them with some discussion point by point:

1. Forcing of Mortality.

There still persists a knowledge of the fact that many colleges and universities did, in the recent past, deliberately force

the mortality of a certain percentage of their entering classes.

2. The Publicized Mortality of Engineering Students.

So much attention has been given to this in engineering discussions that the student, family and counselor's minds are more or less conditioned to the fact that the student has an only 1 in 2 chance of finishing an engineering curriculum. Actually, comparative figures with other college entrants show that engineering is only slightly tougher in this respect. We might add that the Cleveland school system was remarkably pleased with the analysis which Case Institute of Technology made of their own student success history. These results showed a 76% survival of the entering freshman with one-third of the mortality due to academic reasons.

3. The Handling of Entering Freshmen.

The transition from the relatively closely guided career in high school to the entirely "On your Own" technique which has prevailed in engineering and other colleges is to much for many young and immature minds to absorb. Guidance of the individual student and lack of friendly counsel by faculty members tends to leave the young man rather high and dry. He needs someone to coach him through the first few months.

4. The Tough College Professor.

Within the past year a pair of Professors in the presence of a Cleveland school representative and during a discussion as to the failure of a couple of Cleveland boys made reference to the fact that a certain Professor considered it his duty to flunk a certain number each year.

5. Better Admissions Procedure.

The schools feel that admissions procedures should be of the type that would insure a better than 50% success among the entering students.

The secondary school educators are much closer to the families of these young men and are frequently criticized for the financial sacrifice engendered by the failure of a young man in college.

6. Gaps.

It must be acknowledged that some gaps exist between the level of teaching in mathematics, physics, chemistry, English and college expectancy. In Cleveland, the schools do not claim to have their courses in these subjects accurately tuned to the varying interpretations of standard requirements made by individual engineering colleges. A similar situation existed in 1940 among the young women students who sought careers in the nursing professions. The failures in this group were close to the 50% level. Through the cooperation of Professor Margene O. Faddis at the Francis Payne Bolton School of Nursing, Western Reserve University and Dr. Herschel B. Grime, Supervisor of Mathematics in the Cleveland Public Schools, a book was published by the J. B. Lippincott Company entitled "The Mathematics of Solutions and Dosage, including Simple Arithmetic." This book was intended as a guide to the high school teacher and as a practice manual for the entering student nurse and has served as a bridge between the high school and college level studies in that field.

7. Stature of High School Educators.

A high school educator has many feelings akin to those possessed by college educators. They are forced to keep their students in class through high school. This does not change their thinking about the fact that washouts in college reflect upon their teaching ability as well as upon the various abilities of the guidance counselors, principals and other personnel in the system. They enjoy the success of their students just the same as do engineering educators and they are depressed by the failures.

8. The Report of the U. S. Bureau of Labor Statistics.

In spite of the fact that a retraction and new set of charts were published and that *Life* magazine ran a full page picture of the present engineering situation, and

in spite of the fact that reams of newspaper propaganda has shown up, there is still a feeling that things are not quite as represented. The reversal was so complete that the present facts cannot be whole-heartedly accepted. Some of the reports of over-supply which cropped up last year had their beginning in the policies and fears of engineering educators a few years ago. Such a feeling was communicated to several Cleveland school officials as far back as 1946. In the same vein they look askance at the enlisting of girls for the engineering profession feeling that there is too much danger for such action to end up as pure exploitation. To reverse this opinion the Counsel and enthusiasm of successful female engineers must be evident.

Influence of Technical Councils

Another factor entering into the Cleveland situation is its relationship with the Cleveland Technical Societies Council. This Council has been very active in the conduct of career conferences on engineering. Some 40 members of these different Societies helped conduct this year's conferences, one of which was held on the east and the other on the west side of the city. In spite of all their efforts and hard work the value of the conference seems to be diminishing and the success of this year's affairs might be seriously questioned. High School Sophomores, Juniors and Seniors are permitted to attend. In these three classes within the city of Cleveland there are probably some 6000 young men, 2000 of them in the Senior level. A total of 364 of these young men attended the two conferences. A talk was given by one of Cleveland's engineers and was well received by the students present. A series of nine panel discussions were organized to follow the address. A movie was inserted into the program which brought the actual beginning of the individual panel discussions to a point well after 9 P.M. at which time several of the students left for home. The movie, itself, was well made, but we doubt if it could be called psychologically correct for the inspiration of young minds as it made little attempt to tie the student's present experiences into the potential abilities which he might possess. Most of the examples given were too far beyond the scope of the high school mind.

The junior and senior high school students, according to Cleveland Educators, have committed themselves to a course of study. If they have failed to take basic engineering college requirements it is too late, in most cases, for correction. As tough and unreasonable as it seems, under our present engineering college curriculum and requisite admissions procedures, a high school student must make up his mind as to general classification of life work *while still in Junior High School.* Efforts to interest young minds must be directed to and adjusted for that age group.

There is serious question in the Cleveland School System as to the worth-whileness of continuing this conference. If it is to be continued, then greater inspiration, more skillful handling of invitations and the meetings themselves and more effective dramatization of the careers in engineering will be required.

Progress and Problems

During the past few years, engineering has taken on a broader connotation as evidenced by the efforts to inject business and social understanding into the curriculum. Engineering education is preparation for a way of life, just as the study of medicine, of science and of the clergy are ways of life.

Engineering has had a very human function during its existence. The engineer has devoted his every attention to making slaves out of machines and things instead of people. It is the engineer who has lifted humans from slave conditions toward the American ideal of individual human dignity. Our national strength and well-being has grown in proportion to the growth of engineering education. The engineer of the past century has done

more to accomplish the dreams of the world's philosophers than all of the literature and lip service of 20 centuries. Engineering is a worth while kind of life.

This concept, and the present shortage of candidates requires some compromise of past standards and ideals. We must first acknowledge and be sensitive to the problems of the secondary school educator and then proceed to find ways of cooperating whole-heartedly with them. The ultimate people we must influence go beyond those with whom we have been dealing up to the present. In trying to expand the entering Freshman engineering class we are reaching into a different type of family and to a different type of student.

It has been a varying policy in engineering schools to look somewhere in the upper 20% of the graduating classes for prospective engineering students. We are reaching below this now and it is very possible that in the next four or five years you will have to reach way down to graduate 30,000 engineers a year. You may even get down to the average American family where the income as a unit is in the neighborhood of $3500.00 and papa has an average educational attainment of one year in high school. In reaching for talent down to this level we can expect other human problems to enter into the scene which we will not discuss in this paper.

Some Engineering Advantages

The engineering profession has much to sell. There is the essentially very human and established fact that the engineer is a better husband and family man and a good though quiet citizen in his community. We have heard Engineering Deans state that some 43% of the men entering the engineering profession develop into executives and company presidents. There must be some qualities which engineering studies impart or such a large number would not be promoted to positions of executive responsibility. Perhaps this study develops a disciplined mind and at the same time creates a relatively more honest individual.

The engineer, by reason of his ability to organize and direct activity, as well as by reason of his engineering knowledge, has a more flexible earning power than is the case with many an individual. His feeling of personal worth is perhaps as high as that of the medical profession and most certainly there are none higher. There is a patriotic appeal at the moment because it must be acknowledged that we cannot match man for man with the rest of the World but we certainly can match intelligence if we organize ourselves to keep the pipe lines which educate this intelligence sufficiently filled.

Suggestions

We were really pleased to learn recently of the certificates which Purdue University issues to every student who must leave school before graduation for one reason or another. It acknowledges that he has had some engineering study. Much more could be made of this one basic fact and perhaps a slight rearrangement of curriculum in most colleges would make one year of engineering study a definite value, and two years would give a very firm foundation. This will enable a young man to continue through self-study and night school his personal development at a pace which would not normally be possible without this basic training. Cleveland educators suggest that some designation such as "Junior Engineer" might be applied to young men finishing a two year program so as to give more standing to those who cannot afford or cannot master the full curriculum. To many, this point is one which has been neglected by the engineering profession and one which should be capitalized upon as it would help many young men prepare for a better life.

The Counselors and high school educator can be influenced from the industrial angle through employment on special projects or during the summer vacation months. Other efforts to recognize the contribution of these people in the development of young men and the ultimate stature of our Nation could be explored

by Professional Public Relations personnel. Anything at all that would help establish the personal worth of the high school educator and beyond that those things which would permit engineering colleges to acknowledge and honor this worth would help ease and ultimately develop fullest cooperation.

The publicity, the booklets, the movies and every other tool which the engineering profession uses to build up the proper student body will all be helpful. We should not forget, however, that the greatest sales argument in the world is to have someone else attest to the value of your product. The young engineer and *enthusiastic* (an important factor) engineer in industry is the greatest argument for engineering study. To these engineers as individuals we must look for assistance in making the final decision in the mind of the high school graduate and his family. It will be his influence and his persuasion of this student and his parents and upon secondary school educators that will be the greatest single force in helping us to realize our self-set goals. It is this group that must be organized and guided so that their efforts will be adept and meaningful where it counts.

College Notes

The appointment of Malcolm S. McIlroy as assistant director of the School of Electrical Engineering at **Cornell University** was announced. Professor McIlroy, who has been a member of the Cornell faculty since 1947, was awarded the John M. Goodell Prize of the American Water Works Association last year for his work in developing an electrical apparatus to study pressure flows in pipeline networks.

An important new research program designed to provide information which will enable manufacturers to make the automobile a less lethal form of transportation was announced by **Cornell University.** Springing from Cornell's long-established program in air-safety research, the undertaking will strive for improved automobile design to give the rider greatly improved chances of emerging from accidents without disfiguring, disabling, or dangerous injuries. The Cornell Committee for Air Safety Research, which heretofore has confined its interests to air safety, will broaden its activities and change its title to "The Cornell Committee for Transportation Safety Research."

Questions Concerning the Engineering Curriculum

By L. E. GRINTER

Vice President for Instructional Activities, ASEE
Research Professor, Illinois Institute of Technology

In an article published in the JOURNAL OF ENGINEERING EDUCATION for September, 1951, President Hollister has asked many questions that engineering teachers and administrators must answer if progress is not to be denied. The central question is "how is it possible to meet the needs of the world shaking technology of today by use of a curriculum that has changed only in its details but not in its concept for forty years?" President Hollister has used the word curriculum despite the fact that many college catalogues list a dozen or more engineering curricula. One is justified in this choice of wording because such curricula are nearly all designed to achieve the same objectives.

The following list of objectives inherent in single curriculum building raise the question of realism in regard to our present approach to this problem. Our students must be broadly educated; this should invite study of the humanities, political science and world economics. They must have a background of physical science of a more detailed nature than we consider necessary for a major in any other field except for those who would become physicists or chemists. The same may be said for mathematics. At the beginning level engineers must give time, we believe, to drawing and descriptive geometry and later to surveying or process work from which all other students are free. Then they must develop a command of several of the applied sciences of engineering. Eventually they must achieve capacity to design which is the heart of engineering curriculum building. Believing as we do that only economic design is good design we also emphasize costs to a greater extent than any other college except the College of Business. To prepare our graduates to take their places in supervision or administration, which is the destiny of a majority, we accept the necessity for study of personnel relations, business organization, and management. Now add to these objectives the need of every engineer for breadth of knowledge in several fields of engineering and the importance of the mental discipline that only comes from specialization. Is it necessary to continue further or has the elastic limit already been exceeded? Can all of these objectives be achieved to a useful level for most students in four-year curricula?

If your observation of our product leads you to question the success of making the engineering curriculum try to meet so many objectives in so limited a time, what are the alternatives? I suppose they are first *to use more time* or second *to reduce the objectives per student*. If nearly all of our students were destined to spend a lifetime working as engineers, no doubt we would long since have extended the period of training to five or six years. But we know that large numbers study engineering without strong professional objectives. Also, there is no obvious alternative study for many young men who desire to live and who know that

they must make a living within the broad framework of technology. For these students the present curriculum is sufficiently long and perhaps too specialized. But for those whose interests are in professional specialization the curriculum offers insufficient opportunity to lay a firm foundation in basic science, in mathematics, and in the engineering sciences that support specialization.

If we accept these observations as sufficiently true to rule out drastic solutions, such as longer programs for all students, what opportunities remain for facing the questions raised by President Hollister? Must all students be treated essentially alike? Is it reasonable to place those who desire to become professional engineers and those who wish merely to study engineering under restrictions of the same curriculum for four years? Despite great differences in aptitudes should all electrical engineers, for example, receive the same preparation for design? Is it even necessary that all should have the same humanistic background, or might some be allowed to emphasize non-technical studies as background for engineering statesmanship while others might choose the limited objective of becoming a good designer? Perhaps an even more restricted objective would serve for some students while breadth of education would best meet the interests of others.

It seems to the writer that the emphasis upon the multiple branches of engineering in curriculum building may have passed its zenith. Certain needs and opportunities that are becoming more clear are forcing the branches of engineering education to draw closer together again. Research and its special needs is one such influence. Administration is another. Perhaps our interest in developing spokesmen or statesmen for the profession is a third. The question to be raised is whether we can provide the flexibility within individual curricula to take care of the diverse interests of designers, researchers, managers, constructors, salesmen and statesmen? If our answer is yes, we must start to question the concept of a fixed curriculum pattern for all engineers even within a single department of a single institution. Certainly we should then encourage the greatest reasonable divergence between programs in different institutions.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Engineering Research in the Program of the National Science Foundation *

By DR. PAUL E. KLOPSTEG **

Assistant Director for the Mathematical, Physical, and Engineering Sciences of the National Science Foundation

As representative of one of the university members of the Engineering College Research Council for a number of years, it is pleasant to renew associations with this group. Having only recently assumed responsibility for direction of the Mathematical, Physical, and Engineering Sciences Division of the National Science Foundation, I am sure that my profit in getting your views and comments will be greater than yours in listening to this speech. I am grateful for the opportunity to meet with you.

Engineering has been characterized as the art of directing knowledge of the physical sciences towards useful ends. Another summary statement, attributed to the distinguished engineer, Gano Dunn, is: "Engineering is the art of the economic application of science to social purposes." Still another, inscribed on a wall of the headquarters building of the Engineering Societies is: "Engineering is the art of directing men and controlling the forces and materials of nature for the benefit of the human race."

All three of these statements assert, in common, that engineering is an art, namely, the art of directing, applying or controlling something, for the benefit of mankind. Although each differs in form from the others, all express essentially the same thoughts, and we may, I believe, accept them as a fair characterization of our field.

Functions Prescribed by the Act

The National Science Foundation Act of 1950, which established the Foundation as an independent agency in the executive branch of the government, authorizes and directs the Foundation to perform certain functions. Those of particular interest to engineers are:

(1) To develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences; (2) to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering and other sciences . . . (4) to award scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering and other sciences; . . . (6) to evaluate scientific research programs undertaken by agencies of the federal government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups.

These functions, quoted from the Act, contain two points that are worthy of special attention: First, it is unequivocally stated that the Foundation shall concern itself with *basic scientific research;* second, engineering is regarded not as an art but as a science. It is, in fact, called a science. Further along, the Act specifies that there

* Presented before the Engineering College Research Council at the Fall Meeting of the ASEE, Houston, Texas, November 15, 1951.

** On leave from Northwestern Technological Institute.

shall be initially four divisions (with the provision that others may be established by the National Science Board) of which the second is called "Division of Mathematical, Physical, and Engineering Sciences."

Perhaps the extent of the incongruity is not so great as might appear at first sight. As used in the definition of engineering, "art" clearly means skill; and to become skillful in applying the principles of the physical sciences to human needs and desires requires further knowledge that must be acquired through research. Implicit in the concept of engineering, moreover, is the social aspect; there is no engineering unless it be directed towards ends that are useful and desirable to human beings. Science, on the other hand, is completely impersonal in its aims and ideals.

Basic Research vs Applied Science

Ideally, the scientist has but one aim: to penetrate and conquer the areas of ignorance and annex the territory thus gained to the contiguous areas of knowledge. Perhaps this description may serve as a working definition for basic research; perhaps also it may help our thinking about basic research in engineering. If penetration and conquest of ignorance is an essential step in research, engineering may lay equal claim, with science, to the procedure; for science has no monopoly of that which is unknown. It seems quite unprofitable to try to write specifications for ignorance, or to subdivide it into areas. The point of this discussion is that lack of knowledge about applications of scientific principles to a particular situation is ignorance just as truly as is lack of knowledge of the principles to be applied. Hence it seems logical to take the position that research directed towards methods and procedures of applying knowledge towards useful ends is research as truly as that which seeks knowledge of science in the first instance. I am mindful, furthermore, that in seeking to devise the procedures and methods of application, engineering research must always be concerned with the economic and social aspects of its possible results. This makes the research no less basic.

There is another approach to the problem of what constitutes basic research, in general, and basic research in engineering, in particular. In the sciences, it seems generally accepted that basic research has as its sole motive the search for new knowledge. The scientist engaged in it is free to follow his intellectual nose. His procedure is one of pure inquiry, without external program or direction. From his point of view, anything that savors of the practical, or of applications, is not research, but development. He may yield sufficiently to say that it is "applied" research.

To explore this line of thought in the direction of our thinking will require traversing ground which undoubtedly is familiar to all of us.

We begin with agreement with the scientist as to what constitutes basic research in his field, and recognize that the outcome of his efforts is an addition to knowledge and understanding of some physical phenomenon. Whether this knowledge is usable or useful is at the moment unknown. It is possible, and it frequently happens, that in the course of his investigations some evidence of utility appears; indeed, there may emerge from his activity something that has obvious applicability, with economic or social implications. An example is the Steenbock research on the effects of irradiation, by a certain region in the ultraviolet, of certain steroids, producing vitamin D.

Ordinarily the evidence of utility is not so clear. In most cases, the undertaking by which useful applications of principles are found is initiated as the result of some economic or social motivation, for finding, devising, or improving procedures, devices or processes in some well defined area. Those engaged in the work thus formulated may be engineers, or they may be working in the vanguard of engineering, in applied science. For them and from their point of view, their work is basic

research. After they have found out how to apply a new principle, and have demonstrated the feasibility of what they have found, the project enters the engineer's domain. I hasten to say that there is no clearly-defined boundary; the scientist may have to do some engineering, the engineer may have to make an occasional journey into science.

Broadly speaking, of course, engineering is applied science; but in this discussion I conceive of it as applied science plus something more. That something more is a thorough awareness of the economic and perhaps, in some measure, of the social aspects of the general problem. He takes over, and carries the design, or method, or process forward to its economic utilization, including the important functions of initiation, supervision and control of the steps involved by which the product is put in final form for use by the public.

There is another possible avenue of approach to testing whether a given research activity is basic. This is the question of the motive of the research worker. It is held by some that unless the motive is solely to add to knowledge without concern for any other considerations, the research is not basic. Under this conception, it is possible that two people might begin with identical knowledge and arrive at identical results, each under the stimulation of different motives. One of them has no practical objectives in mind. The other has. On the basis of such a test, then, the research would be basic for Worker A but it would not be basic for Worker B. I cite such a possibility only because it illustrates the difficulty of appraising proposals. For some purposes the test of motive might be entirely proper and practicable, but it would seem a little difficult to employ this test in appraising suggestions or proposals to the Foundation.

Each Proposal on its Own Merits

From considerations such as these one may derive some of the intellectual satisfaction that comes from the arrangement of ideas in a logical pattern. Actually, in carrying on the work of the National Science Foundation, we cannot—desirable as they may be—write any rules or devise any standards of measurement that could be applied to a particular proposal to determine whether the project in question is or is not in the category of basic research. It is obvious, in view of our having to deal so extensively with opinion, that no simple criterion, capable of being mechanized, or of being developed into simple routine, can be established, against which to appraise a proposal. That which is basic research to an engineer will in all probability not be so regarded by the scientist, either in the applied field or the fundamental disciplines. Each situation will have to be evaluated with the best judgment that can be brought to bear upon it, and decisions reached in harmony with the broad objectives of the Foundation.

The National Science Foundation is trying to develop its organization and procedure in such a way that only thoroughly qualified persons will be considering proposals for research in any area of science and engineering. Moreover, it is the intent of the National Science Board that basic research in engineering will be supported, whether or not the subjects to be investigated bear the specific label "engineering." We have, for purposes of aiding our own thinking, prepared lists of many such subjects, and members of the Board have found these to be appropriate illustrations of research in engineering. Here are a few samples, illustrative only, and by no means inclusive:

Transient flow in porous media.

Fatigue characteristics of engineering materials under conditions of variable cycle loading.

Fluid friction in unsteady motion.

Surface temperatures of sliding surfaces.

Theoretical study of detached shock waves.

Study of the earth as a thermal source and sink.

Solar energy studies.

Diffusion in liquids near the critical point.

Influence of ultrasonics and microwaves on chemical reaction rates.

Theoretical studies of interaction phenomena of electric charges and electromagnetic fields.

Properties of wave guides, wave guide filters.

Power measurement at radio and microwave frequencies.

New methods of performing mathematical operations with electronic computers.

Intermetallic compounds as high temperature materials.

Correlation of crystal structure of refractories with thermal shock properties.

Correlation of dielectric properties of mica with crystal structure.

Plastic flow and stresses within the grains of metals.

Oxidation of metals at high temperatures and pressures.

Application of measurement and control to research problems in various sciences.

Methods of Financing Research

The National Science Foundation Act provides a large degree of freedom in the choice of means for supporting research. For the most part, such support will be given through financial assistance to organizations and individuals primarily for the conduct of research. In connection with such work there may be necessary field trips or expeditions, development or purchase of instruments or other equipment, and the construction, modification or purchase of laboratories or other facilities.

Direct support of research is, however, not the only function of the National Science Foundation, as is evident from the recital of functions which were quoted earlier from the Act. Accordingly, it is also anticipated that support will be given for education and training of scientific personnel, through the Division of Scientific Personnel and Education, largely by a program of fellowships and, later, of scholarships. Other activities are contemplated, all of which bear directly or indirectly on research in the natural sciences.

Heretofore two methods have been widely used by government agencies for financing research. One of these with which I am sure all of you are familiar is the contract. The basis of a contract is a quid pro quo, that is, the exchange of specified performances. One form of the contract has been the fixed price or lump sum contract under which, when used in research, the contractor agrees to specific performance in return for an agreed upon compensation. This requires that the cost of the work to be done be estimated in advance in fairly specific terms. In basic research it is difficult, if not impossible, to make such accurate determinations. The administrative advantage in the fixed price contract is the absence of a need for supervision of actual costs incurred. The lump sum contract has been used principally by the National Advisory Committee for Aeronautics and the Atomic Energy Commission.

The better known kind of contract used by government agencies in recent years is the cost-reimbursement contract. This type of contract, covering research and development, was first widely used by the OSRD during the war and more recently by ONR and others. It provides for compensation for all costs incurred in the accomplishment of the work. The difficulty of defining costs and of determining what costs have been incurred is probably well known to all of you. Efforts to meet the difficulties have been evolved through a wide variety of specialized forms within the general framework of this type of contract.

Such a contract almost invariably requires elaborate financial and property accounting systems and audits. All of this may prove burdensome, especially in contracts that do not involve large

amounts. They also result in relatively large costs of administration both for the government and the contractor.

Inasmuch as the Foundation is specifically authorized to make grants for the support of basic research, it is now anticipated that this form of support will be most generally used by the Foundation. In the practice of both private and government institutions, a grant is a donation of money, property or other valuable thing usually for the accomplishment of an agreed-upon purpose. Like the contract, the grant takes different forms depending upon the purpose to be achieved and the relationships established between the parties. Typically, the grant is characterized by statements of objectives and essential undertakings. It does not require detailed financial and administrative arrangements. Payments to the grantee are usually made in advance either in total sum or relatively large installments. Reliance is placed on informal understandings rather than legal safeguards although legal protection against deception and noncompliance is preserved. Compliance is achieved principally through continuing relationships between grantor and grantee.

As you are aware, the grant for research has been most widely and almost exclusively used by private foundations.

For many reasons, the grant seems particularly appropriate for the support of basic research by the Foundation. It is anticipated that most projects that will be supported by the Foundation will arise through the initiative of individuals of demonstrated competence who have a keen interest in exploring some particular area and who lack the means necessary to carry on the work with expectation or hope of reasonably early results.

Proposals are now being received by the Foundation. As it becomes more widely known that funds are now available for operation, it is expected that proposals will appear in increasing numbers.

It is necessary at this point to inject a word of caution. Proposals should "come from within," that is to say, from people who have a compelling urge to do basic research in the fields of their specialty. Proposals should not be "dreamed up" for the sake of obtaining a grant. It is the duty of the Foundation to examine not only the subject matter but also the ability of the proposer and the facilities at his command.

Although no special form is required, the staff of the Foundation is preparing a set of suggestions which proposers may follow in seeking a grant. Very briefly, it will be desirable to include in an estimate the following items:

a. Individual salaries of both full- and part-time personnel.
b. Cost of capital equipment.
c. Cost of expendable equipment.
d. Other direct costs such as travel and publication costs.
e. Indirect costs (up to 15 per cent of total direct costs).

Several of these items will raise questions, some of which are difficult or, at the moment, impossible to answer. For example, the publication of results of research is a matter of expense which some government agencies are not permitted to reimburse. On the other hand, the position may logically be taken in matters of basic research that the research has not been completed until its results have been made widely known to others working in the same field.

Overhead Allowances

Another question which I am sure would be asked, if I did not mention it, is the question of indirect costs, sometimes known as overhead or in business as "burden." No doubt many of you have spent many hours discussing this question with representatives of government agencies in connection with the cost-reimbursement type of contract.

In grants made by the Public Health Service and in many of the lump sum contracts of the Atomic Energy Commission, 8 per cent of total direct costs has been used as compared with various percentages ranging between 5 per cent and 100

per cent or more of the direct payroll in the cost-reimbursement type of contract.

In arriving at a suggested figure of 15 per cent of total costs, several ideas have come into the picture. One of them is that the capital equipment employed in the research will in most cases become the property of the institution or organization receiving the grant. Another consideration is the fact disclosed in a survey that 15 per cent of total direct cost may amount to somewhere between 20 and 30 per cent of payroll. Moreover, since we are considering only basic research, namely, the type of research which universities generally consider as part of their normal activity, it may be assumed that they may not be averse to participation to a limited extent, this extent being the difference between the actual indirect costs, assuming these to be known, and those provided for by the 15 per cent of the total. Since there is no provision either for an audit or for advance determination of actual indirect costs, there will be no occasion to discuss the question once a university or other institution has agreed to accept the grant on the basis suggested. Perhaps it is not out of place to mention at this point that grants from private foundations do not provide for indirect costs.

Another important consideration is that with possible rare exceptions, all results of research done under a National Science grant will be unclassified. There will be freedom of publication—a most desirable sequel to a project from the standpoint of the university and an essential one from the standpoint of the scientific community. The value of publication to the investigator and the university is obvious; it is the reward for work well done and for an enlightened institutional policy. Through it the individual and his university gain stature and prestige, and through it they achieve the satisfaction of having added to our knowledge.

Possibly the most cogent point is that in the National Science Foundation something new is added to American science, namely, an opportunity—at the moment a sharply limited opportunity because of a severely restricted budget—for those who have the ability and the desire to do basic research to obtain adequate funds to carry on this work, thus enabling their institutions to meet an obligation and a function that they have long recognized but which they have been unable to fulfill for financial reasons.

Other Considerations

Other questions to which the answers may to some extent be anticipated will arise. The following answers are tentatively given and I say tentative because experience may show the need or desirability for change.

The typical grant instrument will be exceedingly simple. Under it the research worker will not be required to be a bookkeeper or accountant. He will agree to carry on his research under a statement of aim and scope of the work. His performance will be largely the result of his ability and integrity in carrying out his intentions.

The funds allocated by the Foundation for research usually will cover more than a government fiscal year. They will, probably after the present fiscal year, run for several years, and may run as long as five years. Most of you already know that the President's request for an appropriation for the Foundation for the fiscal year 1952 was about $14,000,000, that the House of Representatives cut this to $300,000, that the Senate brought the amount back to $6,300,000, and that the final figure agreed upon in the conference committee was $3,500,000. The point of this comment is that we cannot be complacent and think that because we now have a law, the purpose of which is to initiate and support basic scientific research and other related matters, scientific research is now provided for and can move forward as quickly as the ability and availability of scientists make possible. This is by no means the case. It is quite evident that notwithstanding the four or

five years during which science legislation was in process, there is still insufficient appreciation of the meaning of basic research among the public at large. All of us who are interested in seeing the objectives of the Act realized must continue to work towards the end that from these beginnings an effective organization may develop. The Foundation is definitely in its infancy and a good deal of intelligent care is needed to assure its normal growth. Our task has only begun.

In view of the fact that we are dealing with basic research, it is not anticipated that many inventions will be made. In the event that there is invention, the instrument of the grant will permit the grantee to file for a patent at his discretion with the sole requirement that the Foundation be notified and in case the patent goes to issue, the government shall have a royalty-free license or so-called shop rights.

It is expected that when a grant has been made, the grantee will make an informal report or a series of reports to keep the Foundation informed of the progress of the work.

In a discussion such as this, it is obviously impossible to cover all details. The most important matters pertaining to the administration of the support of research have been presented.

To carry out the support of research and other objectives recited in the Act, an organization is gradually being developed. In the Division of Mathematical, Physical, and Engineering Sciences there is as yet no staff, but we are seeking qualified scientific personnel to head the several sections which will be concerned with the various physical sciences. The eventual size of the staff cannot at the moment be predicted. Under this year's appropriation, we shall have to move with caution.

It is my hope that in this presentation I have not given the impression that we in the Foundation know all the answers or even a substantial fraction of them. As I see it, the National Science Foundation is in something of an experimental stage. It is a great opportunity for the scientists of the country, provided they have the wisdom and whatever other qualities are needed for making scientific research flourish and produce results on a scale never before possible. These results, if the objectives of the Foundation are achieved, namely, the objectives envisaged in the Bush report entitled *Science, The Endless Frontier* and in the Steelman Report, *Science and Public Policy,* will then truly become the firm basis for the further progress not only of our own country but of all mankind on a scale which can be limited only by the imagination, and by the ability and effort that we put into this work.

Mid-Winter Meetings

A conference of the Division of Relations With Industry will be held at the Massachusetts Institute of Technology on February 2, 1952. The theme of the conference will be "The Student as an Individual." A meeting of the Advisory Committee of the Division will be held on Friday, February 1, 1952, at 9:30 A.M. The first draft of the papers to be presented at the June meeting will be discussed.

The Mid-Winter meeting of the Engineering Drawing Division will be held at three New York universities—The Cooper Union, U. S. Military Academy at West Point, and Columbia University on January 23, 24 and 25, 1952. The complete program was published in the November issue of the JOURNAL OF ENGINEERING EDUCATION.

Summary of Resources for University Research

By A. F. SPILHAUS

Dean, Institute of Technology, University of Minnesota

and

JOHN I. MATTILL

Secretary, Engineering College Research Council

The importance of making full and effective use of all of America's power for scientific research and development is manifest today. Urgent requirements for national defense have been superimposed on the growing needs of industry for all kinds of scientific research—both at a time of decreasing scientific manpower supplies. For the first time in its history, the nation's collective budgets for research and development in the physical and engineering sciences are seriously limited not by available funds but by available research capacity.

Already the $1.1 billion military research budget requires 56,000 research scientists and engineers, or 43% of the total available in the United States. In 1952, with the desired expansions and including studies sponsored by the Atomic Energy Commission and other agencies engaged in defense research, military research will require 65% of this manpower supply. Before the outbreak of hostilities in Korea, the nation's annual research and development expenditures were $500 million. By 1952 they must be expanded nearly three-fold, to $1.3 billion. Colleges and universities are responsible for 9% of the present research and development total; they must have at least this same share in the vastly larger 1952 total.[1]

American colleges and universities include within their staffs and faculties an important segment of the nation's scientific manpower—at present about 20% of the 120,000 people now in research in the United States. Fully effective use of college and university potential may considerably raise the ceiling placed on research and development progress.

Early in November, 1950, the Research and Development Board in the Office of the Secretary of Defense reported to the Engineering College Research Council's Committee on Relations with Military Research Agencies its concern with this problem.[2] The Board told the group that the research responsibilities of colleges and universities can be efficiently increased only if the nature and extent of educational institutions' research re-

[1] "Research and Development: The Nation's Balance Sheet in June, 1951," by Dr. Eric A. Walker, JOURNAL OF ENGINEERING EDUCATION, Vol. 42, No. 3, pp. 126–133 (November, 1951).

[2] The members of this Committee include Dean A. F. Spilhaus, University of Minnesota, Chairman; Dr. A. P. Colburn, University of Delaware; Dean W. L. Everitt, University of Illinois; Professor F. B. Farquharson, University of Washington; Professor C. W. Good, University of Michigan; Dr. Paul E. Klopsteg, Northwestern University; Dr. James S. Owens, the Ohio State University; President J. R. Van Pelt, Montana School of Mines; and Dr. Eric A. Walker, the Pennsylvania State College. The survey described on the following pages was carried out from headquarters in the office of the Secretary of the Engineering College Research Council, John I. Mattill, Massachusetts Institute of Technology, with the assistance of Miss Jean P. Stevenson.

sources are clearly established. This pointed clearly to the need for a national inventory of the abilities, interests, and qualifications of educational institutions to undertake research in the physical and engineering sciences.[3]

The Committee noted that such a study, if it could lead to more efficient utilization of these resources, would not only be of importance in the national interest —but would as well have great significance for scientific education. Opportunities to undertake research for national defense may be valuable to colleges and their faculties in a time of reduced teaching loads and increased financial problems. Research, under any circumstances, can make a most effective contribution to an educational program, and the potential importance of this factor is heightened by today's desperate need for well-equipped young scientists and engineers.

The inventory, as finally outlined by the Committee, concerned itself with three general subjects:

1. The number of scientists and engineers available at educational institutions.
2. The particular areas within their professions in which these persons are especially qualified to undertake research, by virtue of professional interests or teaching or research experience.
3. Those unusual facilities for scientific and engineering research which especially qualify an institution for research in a particular problem or area.

To obtain data for this national inventory, the Committee developed a special questionnaire form, designed to be as simple as possible within the limitations of the information needed and to produce answers suitable for mechanical processing and comparison. The most difficult task in formulating the questionnaire was to provide a checklist of research interests and specialties within the broad professional and scientific fields. In final form this checklist consisted of a new combination of features from a number of breakdowns, including forms used by the Human Resources Section of the Research and Development Board, based in turn on older material used in compilations for "American Men of Science," and on the classifications adopted by the Engineering Index.

The Committee was aware of the many shortcomings of the questionnaire process, but no adequate alternative seemed possible to meet the pressing time schedule recommended by the Research and Development Board. Obviously, replies from colleges in their own words emphasizing individual problems and suggestions would provide more worthwhile data than the cold statistical process adopted. But the Committee was unanimous in agreeing that such a desirable procedure was not practical.

The questionnaire form finally adopted was mailed early in February, 1951, to 990 colleges and universities throughout the United States, including all four-year educational institutions presumably offering courses in scientific or engineering fields (as listed in the Higher Education Section of the *Education Directory*, published by the U. S. Office of Education). By May 1, when the inventory was declared completed, replies from 747 educational institutions were on file. Of these, 525 reported personnel available for research in one or more of the physical or engineering sciences. An informal review of the list of institutions from which no inventory or acknowledgment was received suggests to the Committee that substantially all of the national potential for research in the areas covered by this project is reported.

1. Personnel

To determine the numbers of scientists and engineers in colleges and universities —and particularly those available to increase the nation's research and develop-

[3] The critical field of Psychology and Human Resources was added at the suggestion of the Research and Development Board, since data of this nature was urgently needed for that area.

TABLE I

SUMMARY OF PERSONNEL REPORTED IN SCIENTIFIC AND ENGINEERING FIELDS

	Total Number of Faculty and Full-time Research Personnel	Number of (*A*) Considered Qualified to do Research	Number of (*A*) now Engaged in Research	Number of Full-time Research Workers to which (*C*) is Equivalent	Number of Research Workers in (*D*) now Engaged in Research for National Defense	Number of Graduate Students and Assistants now Engaged in Research	Number of Full-time Research Workers to which (*F*) is Equivalent
	A	*B*	*C*	*D*	*E*	*F*	*G*
Aeronautical Engineering	652	597	437	289.7	236.8	566	284.2
Astronomy	279.3	246.8	159.8	105.3	39.5	225	130.1
Ceramics	216	200	156	108.8	42	215	122
Chemical Engineering	735.5	701.5	564	279.8	99.4	1,699	807.4
Chemistry	3,711	3,319.5	2,435.7	1,316.1	506.2	6,949	3,468.4
Civil and Sanitary Engineering	1,698	1,429	654	313.6	112.1	936	443.1
Earth Sciences	1,447.8	1,322	964.2	452.4	172	2,086	861.5
Electrical Engineering	1,497	1,237.5	601.5	288.1	219.1	1,125	456.5
Electronics	1,119.4	1,032	625.6	387.2	313.8	1,107	557.8
Food Technology	755.2	634	420	272.6	52.6	692	346.7
Industrial Engineering	535.5	421	173.5	77.1	14.1	352	108.9
Marine Engineering	78	71	35	17.7	12.5	24.2	13.9
Mathematics	3,297.3	2,261.8	1,167.3	570	209.3	1,496	640.7
Mechanical Engineering	2,002.5	1,660.5	716	327.1	150.5	1,119.5	434.5
Mechanics	963.7	820.5	424.7	213.3	119.3	557.2	244.6
Metallurgical Engineering	487.5	458.5	349.2	187.6	131.7	757	387.7
Mining Engineering	135.5	128.5	82	44.4	11	129	50
Petroleum and Fuels Engineering	209	195	112	72.7	12.5	197.2	81.7
Physics	2,628.4	2,271.9	1,546	866.6	609.3	3,392	1,562.1
Psychology and Human Resources	2,432.4	2,029.2	1,242	554.7	227.1	3,161.5	1,141
Totals	24,881	21,037.2	12,865.5	6,744.8	3,290.8	24,785.6	12,142.8

ment activities by undertaking new responsibilities at their own institutions—the Committee asked each institution seven questions in each field of science and engineering represented in the inventory:

A. How many faculty members and full-time research personnel of equivalent rank are now active?

B. How many of these are considered qualified to participate in research projects?

C. Of these, how many are now active, full- or part-time, in research?

D. To the work of how many full-time research workers (35–40 hours per week) is this activity equivalent?

E. Of this "equivalent number" of research workers, how many are now engaged in research for national defense?

F. How many instructors, graduate students, and teaching and research assistants are engaged full- or part-time in the department or field?

G. To the work of how many full-time research workers similarly trained (35–40 hours per week) is this activity equivalent?

The answers to these questions, tabulated in Table I by the various fields of engineering and science covered in the project, provide an inventory of about 25,000 faculty members and senior research workers, and 27,000 graduate students, instructors, and junior research workers. The total of these, 52,000, is a little above but substantially in agreement with the estimate for university scientists in 1951–52 contained in the Steelman report (based on an analysis of the National Roster of Scientific and Specialized Personnel in 1947), allowing for the numbers of scientists and research workers in fields not covered by this questionnaire.[4]

[4] "Manpower for Research," volume IV of *Science and Public Policy*, report by the President's Scientific Research Board, U. S. Government Printing Office, 1947, page 31.

The totals in Table I show that more than 20,000 faculty members are considered by their institutions to be qualified to perform research, but only 12,700 are active in research. Thus 8,000 faculty members considered qualified to perform research are not now doing so.

An average of 27% of the time of the faculty members reported in this inventory is spent on research activities, and 49% of this research time is already devoted to defense research.

Putting these figures in another way: Of the 25,000 faculty members reported, one-half are active in research; these spend about one-half of their time in research, and one-half of this time in turn is devoted to military research. *This means that one-eighth of the total college effort in these fields is devoted to military research.*

This military research activity is the equivalent of the work of a full-time force of 3300 senior research scientists and engineers—a very considerable strength in the service of the nation and a very reassuring evidence of scientific and engineering resources. Yet 8000 more faculty members not now active in research may still add their contribution to this working force. If this can be done, and they become active in research on a quarter-time basis, the equivalent of 2000 more full-time research scientists is added to our research force. Our defense research in colleges and universities could thus be increased by more than 60%, with no decrease from the present level of the non-defense research effort. A quarter-time research assignment presumably does not interfere with teaching responsibilities and, in fact, might greatly improve the professional work of most teachers.

The inventory's statistics show the variations in these relationships between the various physical and engineering sciences represented. Table II shows, for example, that defense demands are now absorbing 82% of college and university research work in aeronautical engineering; yet in Table III are figures showing that only 73% of those faculty members deemed qualified to perform research in this field are now active. Table IV gives confirmation of one characteristic of academic work in various fields which is well known in less quantitative terms: 77%

TABLE II

PERCENTAGE OF SENIOR STAFF RESEARCH TIME DEVOTED TO DEFENSE RESEARCH

Aeronautical Engineering	82%
Electronics	81
Electrical Engineering	76
Marine Engineering	71
Metallurgical Engineering	70
Physics	70
Mechanics	56
Mechanical Engineering	47.5
Psychology and Human Resources	41
Ceramics	39
Chemistry	38
Earth Sciences	38
Astronomy	37
Mathematics	37
Chemical Engineering	36
Civil and Sanitary Engineering	36
Mining Engineering	25
Food Technology	19
Industrial Engineering	18
Petroleum and Fuels Engineering	17

TABLE III

PERCENTAGE OF SENIOR FACULTY CONSIDERED QUALIFIED WHO ARE NOW ENGAGED IN RESEARCH

Chemical Engineering	81%
Ceramics	78
Metallurgical Engineering	76
Aeronautical Engineering	73
Chemistry	73
Earth Sciences	73
Physics	68
Food Technology	66
Astronomy	65
Mining Engineering	64
Psychology and Human Resources	61.5
Electronics	60.5
Petroleum and Fuels Engineering	57.5
Mechanics	52
Mathematics	51.5
Marine Engineering	49
Electrical Engineering	48.5
Civil and Sanitary Engineering	46
Mechanical Engineering	43
Industrial Engineering	41

of chemical engineering teachers are active in research, contrasted to less than 40% in mathematics, mechanical engineering, and civil and sanitary engineering.

A comparison of the senior faculty and graduate student time on research shows that, on an average, each senior member directs the work of two assistants. Apparently one way of increasing the nation's research potential immediately—and more particularly in the future—is to find means of increasing this ratio.

The figures in Table V show the fields of greatest defense research endeavor in colleges and universities. One-fifth of the college research effort is in the field of physics; one-third is in the fields of physics and chemistry; and nearly one-half is in the three areas of physics, chemistry, and electronics. Add to these fields the defense research work in aeronautical and electrical engineering and that in mathematics and the earth sciences, and more than three-fourths of the total defense effort in colleges is represented. Chemical engineering, food technology, ceramics, astronomy, industrial engineering, marine engineering, petroleum and fuels engineering, and mining engineering together account for less than 10%. This is convincing evidence that colleges and universities are maintaining emphasis on the fundamental sciences. The Committee is certain that educational institutions must continue to resist temptations to undertake extensive assignments in applied research and development.

TABLE IV

PERCENTAGE OF SENIOR FACULTY MEMBERS ACTIVE IN RESEARCH

Chemical Engineering	77%
Ceramics	72.3
Metallurgical Engineering	71.5
Aeronautical Engineering	67
Earth Sciences	67
Chemistry	63
Mining Engineering	61
Physics	59
Astronomy	57
Food Technology	55.5
Petroleum and Fuels Engineering	53.5
Electronics	52
Psychology and Human Resources	51
Marine Engineering	45
Mechanics	44
Electrical Engineering	40
Civil and Sanitary Engineering	38
Mechanical Engineering	36
Mathematics	35.5
Industrial Engineering	32

TABLE V

MILITARY RESEARCH IN ENGINEERING AND SCIENCE IN COLLEGES AND UNIVERSITIES

	Total "Equivalent" Full-time Defense Research Workers in Colleges	Per Cent of Total College Defense Research
Physics	609.3	19.85%
Chemistry	506.2	16.6
Electronics	313.8	10.2
Aeronautical Engineering	236.8	7.74
Electrical Engineering	219.1	7.15
Mathematics	209.3	6.82
Earth Sciences	172	5.6
Mechanical Engineering	150.5	4.9
Metallurgical Engineering	131.7	4.3
Mechanics	119.3	3.88
Civil and Sanitary Engineering	112.1	3.66
Chemical Engineering	99.4	3.25
Food Technology	52.6	1.73
Ceramics	42	1.37
Astronomy	39.5	1.27
Industrial Engineering	14.1	.456
Marine Engineering	12.5	.425
Petroleum and Fuels Engineering	12.5	.425
Mining Engineering	11	.36
Totals	3063.7	100

2. Research Specialties

The complete report on University Research Potential shows in detail the specialties within the engineering and physical sciences in which each participating college reported one or more faculty members with interests and qualifications. The number of schools reporting interest and qualification in each of the special research fields is shown in Table VI. The Committee points out that there is no

necessary correlation between the number of schools indicating interest in a specialty and the total number of individuals available for research in that field. Rather, these numbers of schools may be more characteristic of the breakdowns adopted in the questionnaire than of any fundamental character of the demand for research in each specialty.

TABLE VI

NUMBER OF COLLEGES REPORTING INTEREST OR COMPETENCE IN SPECIAL FIELDS

Aeronautical Engineering	
Aerodynamics	89
Aeroelasticity	38
Aeronautical structures	53
Aircraft design	48
Aircraft instruments and flight control	32
Aircraft internal combustion engines	47
Aircraft materials	32
Aircraft navigation	20
Aircraft parts and accessories	20
Aircraft rocket, jet and turbine engines	45
Airport engineering	52
Air transportation	12
Airways and flight patterns	3
Automatic control systems	23
Guided missiles engineering	39
Hypersonic engineering	19
Supersonic engineering	43
Transonic engineering	23
Astronomy	
Astronomical bodies	38
Astrophysics	70
Bolometry	8
Celestial mechanics	39
Celestial navigation	54
Light measuring devices	47
Photographic techniques and equipment	42
Radiometers	8
Solar radiation	25
Spectroscopic instruments	40
Telescopes and optical instruments	46
Ceramics and Glass	
Abrasive materials	12
Cements and lime	24
Cermets	26
Chemical stoneware	12
Domestic and structural whitewares and pottery	25

TABLE VI—*Continued*

Enamels and coatings	29
Glass	27
Heavy clay structural products	24
Industrial whitewares	19
Processing equipment and plant design	9
Raw materials and processing	24
Refractories and high temperature materials	30
Chemical Engineering	
Absorption and adsorption	80
Chemical reactions and equilibria	16
Electrical separation	16
Extraction and solvent recovery	76
Heat transmission	82
High pressure processes and catalysis	56
Mass transfer	73
Materials handling	20
Measurement and control of process variables	58
Mechanical separation	41
Phase change separation	67
Pilot plant construction and operation	79
Sonic and ultrasonic vibrations	21
Chemistry	
Analytical chemistry methods	313
Atomic and nuclear structures	48
Biochemistry	171
Chemical reactions and equilibria	180
Chemical thermodynamics	151
Colloidal chemistry	118
Electrochemistry	130
Inorganic chemistry	246
Kinetics	132
Organic chemistry	385
Physical chemistry	320
Radiochemistry and tracer methods	115
Subjects of specialized research:	
Agricultural chemistry	62
Alkalies	8
Cellulose and wood	38
Chemical warfare	45
Detergents and soap	43
Explosives	46
Fats, oils and waxes	54
Fermentation	31
Fertilizers	32
Forest products	18
Germicides, insecticides and fungus control	53
Heavy chemicals	13
Industrial wastes	92
Paints, varnishes and colors	38

TABLE VI—*Continued*

Pharmaceutical chemistry	71
Photochemistry and chemistry of photography	47
Rubber and related polymers	54
Synthetic resins, fibers and plastics	60
Textiles	25
Water and sanitary chemistry	64
Civil and Sanitary Engineering	
Cartography and photogrammetry	133
Construction engineering	40
Highway and traffic engineering	101
Hydraulic engineering	112
Hydrographic and reclamation engineering	56
Materials testing and research	139
Paving materials engineering	73
Railway engineering	25
Sanitary engineering and public health	108
Snow mechanics and permafrost	25
Soil mechanics and foundation engineering	125
Structural analysis and design	147
Surveying and mapping	124
Water supply engineering	75
Earth Sciences	
Climatology	120
Crystallography	84
Dynamic and physical meteorology	58
Economic geology	175
Geochemistry	46
Geodesy	19
Geography	31
Geophysics	67
Historical geology	157
Hydrology	68
Meteorological instruments and measurements	69
Mineralogy	142
Oceanography	35
Petrology	139
Prospecting and ore analysis	70
Radar meteorology	12
Seismology	39
Structural geology	156
Surficial geology	130
Synoptic meteorology	48
Terrestrial magnetism	27
Upper atmosphere research	46
Electrical Engineering	
Computing machines	81
Dielectrics and electrical insulation	51
Electrical control	116

TABLE VI—*Continued*

Electrical heating	50
Electrical machinery and equipment	131
Electrical power generation	80
Electrical power transmission and distribution	99
Facsimile and wirephoto	10
High voltage research	41
Illuminating engineering	56
Magnetic materials and measurements	54
Network theory	103
Servomechanisms	101
Telephone, telegraph, and teletype	33
Electronics	
Antennas and wave propagation	106
Communication theory	133
Components	62
Countermeasures	24
Electro-acoustics	61
Electromagnetic waves	86
Electronic circuits and theory	201
Electronic computers	54
Electronic control equipment	125
Electron theory	108
Electron tubes	114
Microwave circuits	101
Miniature and printed circuits	19
Navigation aids and direction finding	41
Radar	97
Radio communication	147
Radio interference	57
Radiosonde	20
Speech security and scrambling	17
Television	50
Food Technology	
Bacteriology and microbiology	129
Environmental food factors	52
Food canning, packaging and preserving	80
Food stability and spoilage	60
Nutrition	120
Production, storage and handling of raw foods	61
Industrial Engineering	
Fire protection	24
Manufacturing analysis	73
Mass production and standardization	59
Materials handling equipment	56
Occupational diseases	11
Plant layout and equipment	100
Production control	93
Safety engineering	56
Training devices	51
Work simplification	83

TABLE VI—*Continued*

Marine Engineering	
Cargo handling and stowage	8
Marine safety equipment	7
Navigation	11
Ports, harbors and port facilities	28
Ship construction	12
Ship design and structures	16
Ship propulsion	16
Warships	6
Water transportation	9
Mathematics	
Actuarial science	68
Algebras	248
Analysis	257
Calculus of variations	121
Cryptanalysis	23
Differential equations	239
Geometry	209
Nomography	67
Operations research	41
Probability	144
Series	156
Statistics	220
Tensor calculus	34
Mechanical Engineering	
Automotive engineering	75
Gyroscopes and gyroscopic instruments	24
Heating, ventilating and air conditioning	134
Industrial furnaces	22
Internal combustion engines	132
Jet and gas turbine engines	61
Lubrication and friction	62
Machinery and machine design	120
Machine tool engineering	63
Mechanical control systems	37
Mechanical properties of materials	75
Power and steam generation and use	97
Refrigeration	93
Stress analysis and photoelasticity	84
Textile machinery	9
Thermodynamics, heat and heat transfer	128
Tropical and low-temperature testing	23
Mechanics	
Dynamics	134
Dynamics of earth action	25
Elasticity and plasticity	105
Mechanics of fluids	116
Mechanics of vibrations	100
Statics	142
Strength of materials	144

TABLE VI—*Continued*

Theoretical mechanics	95
Theory of limit design	43
Metallurgical Engineering	
Corrosion and erosion	52
High-temperature materials	36
Metallurgical analysis	45
Physical metallurgy:	
Fabrication and finishing	38
Ferrous alloys	75
Foundry	56
Light metals and alloys	64
Metallography	96
Non-ferrous alloys	62
Powder metallurgy	39
Theory of metals	61
Welding	54
Process metallurgy:	
Electrometallurgy	33
Ferrous	33
Hydrometallurgy	24
Non-ferrous chemical	23
Non-ferrous pyro	12
Mining Engineering	
Mine exploration and development:	
Surface	25
Underground	24
Mine operation and engineering	27
Mineral preparation and processing	31
Mine safety and ventilation	20
Non-metallic minerals and quarries	17
Petroleum and Fuels Engineering	
Coal and solid fuels	38
Combustion reactions	41
Fuel processing and utilization	29
Gaseous fuels	36
Liquid fuels	50
Lubricants	36
Oil field management	31
Petroleum by-products and derivatives	29
Petroleum production engineering	33
Petroleum refining	32
Petroleum storage and handling	15
Rocket fuels	18
Synthetic fuels and lubricants	22
Physics	
Ballistics	36
Biophysics	39
Cryogenics	36
Electricity and magnetism	243
Electromagnetic waves	104
Heat and thermodynamics	119
High-energy particles and cosmic rays	70

TABLE VI—*Continued*

Mechanics	119
Molecular and atomic physics	124
Neutron physics	51
Nuclear physics	157
Photography	79
Radiation and optics:	
Infrared methods and applications	63
Physical optics	135
Physiological optics	11
Photoelectric phenomena	82
Spectroscopy	168
Ultraviolet methods and applications	48
Visible radiation	48
Radioactivity and isotopes	117
Solid state physics	75
Sound and acoustics	94
Theoretical physics	143
Ultrasonics	44
Underwater sound	43
X-rays	99
Psychology and Human Resources	
Abnormal psychology	169
Aviation psychology	59
Clinical psychology, guidance and counseling	278
Comparative and animal psychology	99
Development psychology	127
Differential psychology	99
Educational psychology	231
Human engineering	97
Industrial psychology	137
Personnel training	136
Personnel utilization	98
Physiological psychology	99
Psychological warfare	31
Psychometrics	191
Receptive and perceptual processes	115
Social psychology, propaganda and public opinion	174

3. Facilities

Though this inventory of research resources included both personnel and facilities, its emphasis was obviously on the number and qualifications of the personnel in colleges and universities. Manpower is clearly the limiting factor in most of today's research and development needs; if manpower is available, necessary equipment to implement research can probably be supplied.

The sole aim of the section of this inventory dealing with equipment was to provide a general impression of facilities at any given institution—an impression possibly useful in evaluating the experience of that institution in scientific research. The Committee also hoped to develop a list of colleges and universities with unusual equipment, sufficiently large and complex so that its availability at a specified school is an important factor in the location of research there. The Committee feels confident that the inventory of equipment and facilities developed as a part of this project will be a useful guide in specific instances; but absence of listed equipment should not be construed as lack of facilities and research experience in a given field. Therefore, the data reported is not the kind from which generalizations can be drawn.

Concentration of Research

The tendency to concentrate responsibility for federal research in a limited number of institutions is a very natural one—but one which has unfortunate implications, of different sorts, both for the schools involved and for those not selected. An appropriate amount of research may be most beneficial to the educational processes in a college or university; but over-emphasis on research may impose responsibilities encroaching on effective teaching.

An analysis of the University Research Potential inventory shows a high concentration of defense research projects in a few educational institutions: fifteen colleges and universities account for one-half of the total faculty time spent throughout the United States on defense research, while these same institutions account for only 20.5% of the faculty and senior research staff members.[5]

[5] Eleven schools account for 50% of the federal research and development expenditures in universities over the past three-year period, and 65 schools account for 90% of the contracts, according to Research and Development Board figures. The difference between these Research and Development Board statistics and those developed in the present inventory apparently derives from

In these 15 "favored" schools, 75% of the faculty are active in research, and 70% of their research time is devoted to defense research. At least 85% of those faculty members considered qualified for research are active in it. *A combination of these figures shows that one-third of the effort in these 15 schools is devoted to defense research, compared to one-eighth in the average of all schools.*

The 510 educational institutions responsible for the other 50% of the defense research time reported in this inventory have nearly 80% of the faculty members and 66% of the graduate students recorded. In these schools, an average of 45% of the faculty members are active in research, but only 38% of their research time is devoted to defense activities. Only 55% of those considered qualified are active in research. *Again to summarize, in the case of this large number of institutions: only one-twelfth of the total faculty effort is in defense research, contrasted to the one-third figure found above for the "big 15."* These results are open to two interpretations: either the great number of educational institutions are not undertaking their proper share of defense research responsibilities, or the larger schools are overemphasizing defense research at the expense of educational activities.

The character of this research concentration is still more clearly shown in an analysis of the research at a group of typical highly-endowed, small liberal arts colleges. In these schools 60% of those considered qualified are active in research, 50% of the total faculty has research underway, but less than 20% of the research time is devoted to defense research. *To summarize again, in this case only one-thirty-second of the total faculty effort is in defense research.* (This figure applies equally well to women's, men's and co-educational colleges in this total group.)

the fact that substantial full-time research staffs involved in large-scale defense research projects are not reflected here.

Conclusions

Modern research and development may make unusual demands on those who undertake it, in terms both of equipment and personnel. The increasing complexity of all scientific research—and of its applications in the military arts—is well known. Yet there remain a large number of defense research needs, even those lying outside the range of fundamental research in its narrowest definition, which can readily be provided in packages suitable for the small college laboratory. It is in such laboratories that the greatest potential for increasing our national research and development effort lies, and the Committee is certain that the increasing demand for federal research must involve a more complete utilization of these units.

Another way in which the tremendous deficit in defense research may be aided, not only immediately but with important implications for the future, is by increasing the ratio of graduate students to full-time senior faculty and staff on research projects in colleges and universities where graduate education is underway. Department of Defense research administrators should recognize and encourage contractually the participation of graduate students in their projects. Such activities are an important continuing source of the senior scientists of the future—and also have an immediate utility in getting the job done now. Shortsighted policies in the calling of young scientists for military service can defeat these vital objectives.

Industrial research needs are also grave today, and many of the implications which this report may have for defense research apply as well to investigations meeting the needs of technical industries.

Copies of the full report on University Research Potential, giving full information on all individual institutions included in this national inventory may be obtained from the Secretary of the Engineering College Research Council at Room 7–204, 77 Massachusetts Avenue, Cambridge 39, Massachusetts, for $1.00 each.

Relations Between Nuclear and Electrical Engineering*

By DR. ERNST WEBER

Head of Department of Electrical Engineering, Polytechnic Institute of Brooklyn,

This might be a rather ill-timed attempt to talk about educational problems in connection with prospects for peace-time applications of nuclear power. However, the government is spending enormous sums of our money in about eight national and industrial laboratories already set up for the systematic development of nuclear power plants, so that it would still seem appropriate to explore the services that electrical engineering can perform, and to evaluate whether we might not render better service by planning curricula in nuclear engineering.

It seems clear that electrical engineers contribute significantly to the progress of the atomic power development. Of the over 4000 engineers associated with the technical research and development phases of the atomic energy program as of June 1950 [1] roughly 900 were electrical engineers, being second only to the chemical engineers, who numbered approximately 1400, or about one-third of the total.

Nuclear Engineering

A seemingly simple definition of nuclear engineering as stated by Mr. Luntz, the editor of *Nucleonics*,[2] is "design, construction, and operation of nuclear reactors." This appears also to be the scope accepted by Dr. L. B. Borst, the chairman of the Reactor Science and Engineering Department of the Brookhaven National Laboratory.[3]

Granted that nuclear reactors could be rather important units in themselves if we were at the point where design, construction and operation were a reasonably frequent requirement, could not any number of analogous kinds of engineering be similarly defined? One could at once think of Water Power Engineering, Railroad Engineering, Draw Bridge Engineering, etc., all of which recognize the distinct phases of design, construction and operation.

Tendencies towards such specialization have frequently existed and have induced attempts to formulate distinct curricula for each one of these and many more kinds of engineering. But, is it desirable, or indeed advisable, to let our engineering curricula degenerate into the training of technicians for a specific and narrow field? Should we not rather consider this specialization as the unavoidable byproduct of acquiring "experience" in a field?

Not long ago, any problem contaminated

* Presented before Section M on Engineering at the Annual Meeting of the American Association for the Advancement of Science, December 26, 1950, Cleveland, Ohio.

[1] Philip N. Powers: "Engineers for the Atomic Energy Industry," paper delivered June 22, 1950 before ASEE Annual Meeting, Seattle, Washington.

[2] J. D. Luntz: "Education in Atomic Energy," *Nucleonics*, 7, No. 1, p. 3, July 1950.

[3] L. B. Borst: "Opportunities for Engineers in the Field of Nuclear Engineering," *Jl. Engg. Educ.*, *40*, pp. 424–428, April, 1950.

with the adjective "nuclear" made it at once mysterious and placed it practically outside the conventional engineering thinking. Upon reflection, it should be quite clear that the design, construction and operation of any physical system still must follow the same basic engineering principles which we are endeavoring to convey to our students. This was very well expressed recently by Dr. W. E. Kelley, the manager of the New York Operations Office of the A. E. C.[4] "Engineering today is admittedly more complicated than ever before but it is still based upon sound and thorough understanding and application of well-known engineering principles, the kinds of things we learn in the first few pages of the engineer's handbook."

Fortunately, after an upsurge of suggestions to rush into new curricula on "nuclear engineering," it has been fairly well agreed now that it might be too early for any serious consideration of such a radical step. Indeed, a special committee of the American Society for Engineering Education was set up early in 1950 to study the "Implications of Atomic Energy for Engineering Curricula" and to prepare a preliminary report on its findings as guidance for engineering schools which might be pondering the curriculum problem.

Training Specialization versus Broader Basic

It is, of course, true that the attempts to construct nuclear reactors led into many new problems of engineering design, such as purification of the prime fuel, the uranium, a proper subject for chemical engineers; or the design of high pressure pumps which have to handle highly corrosive fluids under conditions where little servicing can be allowed, a challenge to mechanical engineers (including metallurgical engineers); or the treatment and disposal of radioactive waste liquors, a problem with which the civil engineers and particularly the sanitary engineers need to grapple. But these are in fact all old themes appearing in new variations, they are problems for which the progressive engineer, who keeps on growing in his field of study and practice, will find the answer.

How can the progressive engineer develop to be useful in nuclear engineering? How can we prepare him best for this later growth? One way is obviously to modify the conventional curriculum in the direction of nuclear science and related subjects and to brew a new variety with the label of nuclear engineering. The other way is to prepare the student throughout his study in a manner that he can change his field without having to start an entirely new professional life; this requires also changes in the conventional curriculum, but of a different kind.

The choice is then between more specialization and broader basic study.

Specialization is extremely valuable in industrial organizations where ready answers represent direct savings; or in the complex business of law and government where so much is decided by precedent. But specialization means almost automatically a certain narrowness, a loss of contact with the greater world of ideas, of factual relationships, which basically is necessary for real progress. Many of the major contributions in the sciences were made by men who related phenomena in seemingly unrelated fields!

More Branches of Engineering?

Should we deliberately introduce specialization into engineering education beyond the one imposed by the sheer limitations of the capacity of human brains? Have we not gone too far already in this direction by allowing the original four major stems, namely chemical, civil, electrical and mechanical engineering, to split further and establish subdivisions within each of them? The four main stems have a rather natural origin and scope, to wit:

Civil engineering, the oldest of the engineering arts, deals with structures for housing, transportation, and sanitation, i.e., for the requirements of plain civil

[4] W. E. Kelley: "Engineering in the Atomic Age," *Nucleonics*, 7, No. 1, pp. 5–8, July 1950.

life; even the most primitive of social organizations practices civil engineering;

Mechanical engineering, the second oldest branch, is the expression of inventiveness of man to make life easier by creating mechanical implements for all chores; here belong the early waterwheel, the steam engine and the most intricate gas turbine with their tremendous influence upon the more primitive ways of housing, transportation, and sanitation. Application of such machines on a larger scale laid the first and modest basis for the industrial revolution;

Electrical engineering, a relatively young offspring of physics, has harnessed "electricity"—a non-fluid, a substance, if indeed it might be called one, which it is dangerous to collect, which is a myth to the layman, and which is friend to the expert only through proper use of terminal posts!! This electrical engineering is probably the greatest single cause of modern industrial strife and the surest measure of luxury of a nation because it provides untold varieties of subtle stimulation of laziness. It provides probably the strongest spur for a completely materialistic view of life.

Finally, chemical engineering, the youngest of the engineering arts, deals with industrial utilization of chemical processes, many of which had been known since the middle ages, such as preparation of alcohol for various purposes, of glass and glazes, and others. In its modern version, with large scale reactors, its most attractive phases are the preparation of cosmetics, and its most deadly phase is the development of explosives up to the various "atomic" bombs.

Unless man finds some entirely new substance or process, these four divisions seem to encompass all possible diversifications of utilitarian activities. True, in some instances combinations of parts of two or three of these divisions are desirable, but it is very questionable whether one must rush out to create a new kind of engineering, notwithstanding the ambitions of its protagonists.

Broader and More Basic Study

Should we not draw the conclusion that we do not need more specialization but that we do need broader and more basic study? Should not the training be so that the engineering graduate will find it possible to go into any new field, as it opens up during his life time?

Engineering is ever dynamic, ever seeking new and more economic solutions to problems which in themselves are very old, indeed, such as housing, transportation, and sanitation. Thus, engineering education cannot rest satisfied with present knowledge and present practices, it cannot teach the past without projection into the future; indeed, engineering education must be for the future! If we need to explore the use of new materials in the design of an engine, a reactor, or what have you, we turn to the creative engineer who knows how to get the basic data needed for such a design and will carry through on the basis of this data, with well established generic principles. The real professional engineer must be able to see the kaleidoscopic, unending variety of special forms that any one natural law can assume, under the varying conditions of the dynamic technical world.

Now it seems that so-called Nuclear Engineering clearly demands a broad background and training, more so perhaps than certain less active branches of engineering. In a recent paper in the JOURNAL OF ENGINEERING EDUCATION,[3] Dr. Borst enumerated several questions, now rampant, which presumably require entirely new approaches for their solution: "Can we breed fissionable material?"—"What is to be done with atomic ashes that stay hot for centuries?"—"Can we build atomic powered airplanes?" Surely, these are perplexing questions at this point, and their answer might not come from any one kind of engineer, whatever his designation. But then, similar situations have existed before, and we have had

[3] L. B. Borst: "Opportunities in Nuclear Engineering," *Jl. Engg. Educ.*, *40*, pp. 424–428, April 1950.

to revise the conception of every major stem of engineering, as new ideas arose, and new fields of application opened up.

No amount of engineering training, however specialized or general, can generate by itself ideas in the student's mind. Engineering training can only lay a foundation upon which synthesis of new ideas can be initiated by the catalytic action of the bright mind; and if we need new ideas, we do indeed need the bright minds! The only manner in which we can help as teachers is to create as fertile a foundation as possible upon which the synthesis can take place, and this is certainly not by specialization, by new curricula, by teaching more about less—it can only be done sensibly by broad exposition of the fundamental laws, by recognizing the basic generic principles, from which springs the conception of the problem as a concomitant of its solution!! This is, indeed, the most typical aspect of engineering as contrasted with all other professions: the conception of the problem in a form that spells its solution!

It happens that we have in electrical engineering a perfect illustration of the wrong way of trying to improve upon curricula. With the precipitous development of the radio engineering field, a considerable number of engineering colleges started at once to create two options in electrical engineering: the traditional one for the power field, with practically no change of the good old set of courses, fossilized by practically 20 years of repetition; and a new one for the radio field, which wanted nothing of the heavy machinery courses.

Well, only 10 years ago, preparations started for World War II, and one of the great new problems was "electronic control," such as control of turrets, of antiaircraft guns, of radar tracking devices, of homing torpedoes and so on. A vast new field opened, which required—as if by design—the most intimate combination of power engineering and of electronic engineering. Neither the old-fashioned power engineer, nor the newly-born radio engineer, was equipped to tackle these new problems by themselves. The abler of either class rushed to special courses to balance out the deficiencies created by a premature incision in the curriculum, which disregarded the basic necessity of fundamental training in both fields in order to be reasonably prepared for any new developments, wherever they might come from!

The schools that have had a guiding educational philosophy did provide for a reasonable adjustment to the new developments. Actually, it is fairly well agreed among these latter that undergraduate curricula in electrical engineering should have a maximum of common ground and that the first three years of electrical engineering need not provide specialization. The fourth year might provide optional courses in power, in control, and in communication, with strong advice to secure as broad a training as possible, because of the unpredictable changes in emphasis that might occur in years ahead.

In the graduate schools of electrical engineering, there has been a noticeable divergence of objectives. Some schools consider the Master's program as providing for specialization with intensification of study in a selected narrow field. Other schools, and fortunately a growing number, make the Master's program a very basic one, leading to a critical understanding of the fundamentals. These latter programs include required courses in mathematics and physics so as to permit a broader evaluation of the generic principles, and of their applications, and to emphasize the relatively small number of really basic experimental laws and accepted hypotheses on which the whole structure of any theory rests.

It should be obvious that the second alternative is by far the more suitable for advanced training of engineers, who are to be leaders in research and development, and pioneers in new fields of engineering endeavor. It is the latter group which permits, with relative ease, any adaptation to new combinations of the subject matter of two or more engineering branches.

At the doctoral level, it is generally ac-

cepted that the thesis must be an original contribution to research; however, the course requirements are as diversified as the institutions giving the doctor's degree. In our own case, we practically prescribe a minor in physics, and a minor in mathematics, which we feel to be necessary in order to assure the proper caliber of research work for the doctor's degree.

Training for Nuclear Engineering

How is this all related to Nuclear Engineering? What need be done to the curriculum in electrical engineering to create a practical possibility for the training of men useful in nuclear engineering? Perhaps the answer to this broad question can be given best by way of illustrations.

1. Take first the power aspect. The nuclear power plant as now projected [5] will have the same component structures as any steam-electric power generating station, except that the fuel in the conventional boiler plant (either gas, oil or coal) is replaced by the excess heat of fission. This will, of course, require a number of special safeguards, dealing with the radioactive waste products to prevent the transmission of radioactivity into materials used in the boiler plant, and to protect against harmful levels of radiation by means of shields, etc. As far as the electrical power engineer is concerned, he needs to know about the "hot part" of the plant just as much as he is now learning about the conventional boiler plant for the production of steam by coal, oil or gas; or about the hydraulic installations in the case of hydro-electric plants. He does not need to be a nuclear scientist, nor does he need to really understand the process of fission, in order to appreciate the effects.

On the other hand, if there be a nuclear engineer who can design and construct the nuclear reactor— and this might well be a good chemical engineer—he will certainly not be able to go much beyond the steam pipes connecting to the turbine, without losing confidence in his design ability! It takes the teamwork of the electric power engineer, the engineer for the prime mover, and the engineer designing the primary energy source of whatever nature, in order to build a successfully operating, practical, power plant.

To do his part well, the electric power engineer can get now, in the graduate school in technical elective courses, the requisite knowledge with respect to prime movers and prime energy sources, as far as hydraulic power plants and conventional heat power plants are concerned. This means, then, that some of these graduate courses, like Thermodynamics, Heat Transfer, and Power Supply Economics, should include examples for pertinent nuclear reactor problems, and that elective courses such as Atomic Physics, Nucleonics, Radio-activity should be introduced for full graduate credit.

2. For the detection and measurement of radio activity, many electronic devices have been developed, which belong to the field of "Nuclear Instrumentation" which, in turn, is part of the broader field of electronic instrumentation.[6] Perhaps most important are the instruments used for radiation protection,[7] either direct personnel instruments, or survey meters, or finally, monitors which act as warning devices. Next in importance are the great variety of laboratory meters, counters and recording instruments, some involving highly complicated and specialized electronic circuits.

The so-called eletronics engineer receives in his under graduate years a great amount of basic training in the design of elementary circuits, such as simple amplifiers, oscillators, detectors, and modulators. The important aspects of instrumentation, however, requiring the integration

[5] C. G. Suits: "Development of Useful Power from Nuclear Fission," *Electrical Engineering, 69,* No. 6, pp. 523–528, June 1950.

[6] W. E. Shoupp: "Electronics in Nuclear Physics," Proc. Inst. Radio Engineers, *36,* pp. 1518–1526, Dec. 1948.

[7] K. Z. Morgan: "Instrumentation in the Field of Health Physics," *Proc. Inst. of Radio Engineers, 37,* pp. 74–82, Jan. 1949.

of the elements into systems, necessarily goes beyond the scope of the four-year program; they are taken up in several elective graduate courses, into which, of course, applications of nuclear instrumentation can well be included.

3. The dangerous intensities of radiation close to the observed physical phenomena and chemical reactions, both in the experimental laboratory, as well as in the nuclear furnace, make it necessary to institute remote control in rather elaborate fashion. Again, the specific problems belong to the now well-established field of servomechanisms, or better, "feedback control systems." Because of its general importance, and its basic relationship to electric power and electronics, attempts are being made to include an introductory course in the senior year as one of the technical options. Courses of more or less advanced type are practically standard in the graduate electrical engineering curricula, and hardly need modification to be of direct service to nuclear engineering. This covers also the observation of the physico-chemical interactions by applying stereoptic television so as to actually "see" phenomena, and yet be located outside the range of harmful radiation.

Thus, the entire scope of graduate electrical engineering training will eventually be related to the problems of nuclear engineering. To be of greatest service, the electrical engineer, inclined to work in the field of nuclear problems, should take the opportunity of learning the principles of nuclear physics, without necessarily becoming a "nuclear engineer." But the burden of this training must be on the graduate level, since it cannot be placed upon an undergraduate curriculum of four years. Even the extension of engineering programs to five years has rarely been used to give greater range of technical education; it is usually designed to add more of the general education in history, economics, languages and the like, in order to restore some balance to the educational diet.

Conclusion

I strongly feel that if we give to the young bright people a solid foundation of fundamental knowledge in the undergraduate school, and impress the fact of the dynamic development in science and technology, we can rest assured that they will be able to branch out into all the attractive and challenging new fields, with vigor and intelligent imagination. It is not necessary and, indeed, it might be harmful to stress specialization at too early a point in the educational program. In the end, progress in Engineering as well as in Science depends upon new ideas, and these germinate best in the rich soil of broad and fundamental knowledge.

Agricultural Engineering Curriculum at the University of Illinois*

By E. W. LEHMANN

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The end point in any program of education is action. That is, the fundamental purpose is to get people to act properly under all circumstances; do a better job; and be responsive to the needs of and to serve society. The purpose of a specialized engineering curriculum is to get people to "perform" better within a particular field. To attain this objective in engineering, the individual must be interested, enthusiastic and informed, and also have a competence in technical training and skill within the field of specialization in which he expects to find employment. This statement should be considered an argument for the provision of options, and not a debate on the relative merits of the general curriculum and the option plan, both may be needed.

We look to the home, the church, and the elementary and high schools to educate people to live and to act properly. We also expect everyone to have some basic knowledge of mathematics, physics, social and life sciences and some ability to express himself clearly. In a large part, education will continue to be a responsibility of the home, the church, and the elementary and secondary schools. It should be recognized that many of our most progressive and successful citizens never went to college.

Many students enter colleges of engineering, however, without a clear-cut purpose or an understanding of many life problems. They lack the disciplines which are essential to a well-trained engineer. Fortunately, most students who enter agricultural engineering have a reasonably good idea of what they want to do, and when they finish the sophomore year, they know the branch of agricultural engineering for which they want to prepare. They recognize that there is as much difference between a job in the implement industry and a job in the farm structures field as there is between mechanical engineering and civil engineering. They recognize that the agricultural engineering "major" in either of these divisions provides the same basic technical training with additional courses that better qualifies them for the work they want to do than if they followed the curriculum in either mechanical engineering or civil engineering.

Early Problems

The earlier graduates in agricultural engineering, many of whom went into college work, did not recognize the clearly defined divisions of agricultural engineering. Many departments were small; some were one-man departments. This man had to develop and teach all branches of agricultural engineering. Under such circumstances, the need for a general training that cut across all branches of agricultural engineering can be easily understood. Courses in farm machinery and farm buildings dealt largely with ap-

* Presented before the Agricultural Engineering Division of the ASEE at the 59th Annual Meeting, Michigan State College, June 28, 1951.

plication, practical design and functional requirements, with little attention to research, theoretical design, and development. At that time, little or no attention was given to crop processing, rural electrification and soil conservation.

The majority of the agricultural engineering graduates who went into industry during this early period were selected for positions where their knowledge of agriculture and a broad understanding of engineering were more essential than specialized technical engineering training. This apparently remains true in certain work, but not where a high degree of engineering competence is required.

Trends Toward Specialization

Now agricultural engineering has become much more highly specialized. Individuals who work in the college departments make their contribution when they concentrate their attention on subject matter within a relatively limited area. This specialization corresponds more nearly to what has existed for some time in the older branches of engineering.

It is evidenced in the technical sessions at the annual meetings of the American Society of Agricultural Engineers and by the demand for graduates with special training. At the technical agricultural engineering meetings, there are a few joint sessions which emphasize the relationships which exist between the different technical branches of agricultural engineering. For example, a good soil conservation practice may require a change in machinery design. In advancing rural electrifiaction, the farm structures specialist has the ability to plan buildings to make equipment installation and power application effective.

We have men who are nationally recognized in the farm structures field; the same is true of men in the farm machinery field. These men would not presume to be equally qualified in other fields as in their speciality. It is likewise true of men in narrow fields of civil engineering and mechanical engineering.

Only in recent years has the farm machinery industry looked to the agricultural engineering departments for men qualified as farm machinery designers. They want men who are definitely interested in this specific area of work.

We find that agricultural engineering students who expect to do engineering work want specialization. Moreover, we believe it is essential that they have such specialization to be sufficiently competent to meet competition. The demand by employers for men with specialized training comes not only from farm implement companies who want men to do farm machinery design, developing, testing, or research work but from other organizations who also want men trained in specialized lines. For example, in a recent contact with a representative of a fuel company, I was told they wanted to employ a man trained in power and machinery. This employer was not interested in a broad training covering the whole field of agricultural engineering. Likewise, the rural electrification superviser of a large public utility company was looking for an agricultural engineer who had majored in farm structures. It seemed essential that he should have a farm structures man on his staff to solve problems involved in planning the installation of equipment to improve labor efficiency around the farmstead. A large manufacturer of tractors and earth moving equipment recently selected two Illinois agricultural engineering graduates whose major was in structures and soil and water engineering, in preference to two civil engineers.

The student who completes the requirements for a B.S. degree in Agricultural Engineering under the option plan is better prepared for graduate work in the particular field in which he has majored. To be able to take the advanced graduate courses in design, it is essential that the necessary undergraduate prerequisites be

taken. Agricultural engineers who graduate at the University of Illinois are qualified to major not only in agricultural engineering but in either mechanical engineering or civil engineering, depending on the option completed. With these qualifications, they may proceed directly toward the Doctor of Philosophy degree in either of these areas of specialization.

We believe an agricultural engineer should be well trained in at least one phase of subject matter to adequately serve his company, his clients, or the public, and to meet effectively the competition of men graduating from other branches of engineering.

Areas of Specialization

It is generally recognized that agricultural engineering covers at least five divisions or areas of specialization. The four most common are: Farm power and machinery, farm structures and housing, soil and water engineering, and rural electrification. The fifth is crop processing. The latter is largely a mechanical operation, utilizing the basic principals of physics, thermodynamics, heat transfer, air flow, and power application.

To be well trained in one field, the engineer should be qualified to do design in this field. If it is required that he have approximately equal training in all agricultural engineering subject matter divisions, it becomes impossible within a 4-year period to take sufficient training to become thoroughly qualified to do design work in any one of them. At least, the student completeing the general curriculum cannot be expected to have equal or greater ability than the structural engineer who graduates in civil engineering, or the machine designer who graduates in mechanical engineering.

The practice of providing options in other curricula is well established. In civil engineering, for example, there are construction, highway, hydraulic, railway, sanitary and structural options. In electrical engineering there are electric power engineering , communications and electronic engineering, and illumination engineering options.

To meet the engineering needs of agriculture, we have provided only two options. Our reason is that two or more branches of agricultural engineering are so closely related, they require the same basic training, they can then be correlated and integrated into one program.

First, let us consider the option of farm structures and soil and water conservation. In both of these, basic training in structural design and materials is essential and important. Civil engineers who take similar training are employed in the same fields, but *they lack the agricultural training and the applied agricultural engineering courses.*

In the power and machinery option, the students have the same basic training as is given to mechanical engineers and the same sequence of mechanical engineering design courses. To qualify them further for work in the tractor and implement industry, they are required to take courses in farm machinery design, farm power, and special problems. We are confident that the students who complete this option are better trained for the implement industry than are mechanical engineers.

High School Preparation

A curriculum is not static, but always dynamic; it should be and is subject to change. At the University of Illinois the curriculum is now in process of change to meet the present demands. High schools will assume a greater responsibility for the training in mathematics. Community, state, national, and international problems require that we do something to provide more training in the humanities and social and life sciences. An effort is now being made to provide at least one broad educational course each semester.

In agricultural engineering, we now have 14 semester hours required in the latter group. To attain the objective of 24 hours, which "cannot be attained" according to some engineering staff members, we must adjust our requirements in agricultural engineering to provide additional hours for electives and the general courses. This can be more easily done under the option plan.

At present, the option plan permits the student not only to take the basic courses taken by all engineering students, and the essential basic courses in agriculture, but also a series or sequence of engineering design courses: (1) a series of 14 semester hours in civil engineering design, in conjunction with, or prerequisite to advanced work in farm structure, and soil and water engineering, or (2) a sequence of 14 hours of mechanical engineering in thermodynamics, mechanics of machines and machine design, along with the advanced farm power and machinery courses.

In the option plan, approximately two-thirds or 96 credit hours of the required work in the agricultural engineering options is *identical* with the requirements in either civil engineering or mechanical engineering. This includes approximately thirty hours of advanced engineering subjects in the junior and senior years. There are 48 hours of either option courses or electives in the fields of specialization.

The basic agricultural courses include farm crops (four hours), soils (five hours), and farm management (three hours). These are a part of the training of an agricultural engineer in each of the options or specialized fields.

To make clear the close adherence to basic engineering curricula, and yet show the agricultural engineering specialization, the following comparison of the farm structures and soil and water engineering option in agricultural engineering with the general option in civil engineering is used as an illustration:

HOURS COMMON TO THE TWO CURRICULA

	Agricultural Eng. (Semester Hours)	Civil Eng. (Semester Hours)
Freshman year identical	37	37
Sophomore Physical Education and Military	4	4
Sophomore Mathematics	8	8
Physics	10	10
Electrical Engineering	3	3
Economics	3	3
Theoretical and Applied Mechanics	13	13
Identical Civil Engineering Courses	18	18
Total	96	96

HOURS NOT COMMON TO THE TWO CURRICULA

	Agricultural Eng. (Semester Hours)	Civil Eng. (Semester Hours)
Surveying	3	10
*Geology	3	3
Botany, Crops, Soils, and Farm Management	15	0
Mechanical Power Equipment	0	3
Introductory Agr. Eng. Courses	6	0
Specialized Courses	15	18
Approved Electives	6	14
Total	48	48
Total Required for Graduation	144	144

* Agricultural engineers are permitted to take either Agricultural or Engineering Geology.

It should be recognized that with a "narrow stem" of agricultural engineering training in the junior and senior years affords an opportunity for more electives than is possible in a curriculum that covers the general field of agricultural engineering. This is a decided advantage in meeting the demands for more training in the social and life sciences, humanities, and free electives.

Engineering curricula are notoriously deficient in these courses. Curricula that do not attempt to cover the whole field of

agricultural engineering subject matter make possible specialized training in agricultural engineering and a broader training in other fields of subject matter. This means greater competence in at least one division of agricultural engineering, and better training to meet other life problems.

Conclusion

In conclusion, we should recognize that:

The public not only expects a reasonable success vocationally or professionally of all college and university trained engineers, but also expects that they shall assume a certain amount of leadership in local, county, and state affairs.

It is a mistake to assume that the student who arrives on a college campus has attained from his home and secondary and high school training the competence needed in citizenship, in human relations, and in living. The option plan will permit a broad training in life and social sciences, and in the humanities.

It is possible to secure competence as a designer of either machines or structures in a four year curriculum with options and with a broad base of fundamental engineering training, but such a curriculum does not permit competence in all branches of agricultural engineering.

The various technical branches of agricultural engineering are just as precise and deserve as thorough technical training as branches of other fields of engineering.

The agricultural engineer must have a greater competence in the field of farm machinery design or farm structures design than other engineers if we are to have a feeling of assurance that the agricultural engineering curriculum is justified.

The agricultural engineer, like engineers in other branches of engineering, is expected to be able to function either in designing, testing, developing, and servicing in the machinery and power field; or in designing and construction of farm buildings and structures in the soil and water engineering field. In either option with electives, he may qualify for rural electrification work.

Whether he be trained in one option or in the other, he may do research or sales work, or he may cast his lot in the field of education as a teacher. Finally, with years of experience and demonstrated ability and an understanding of the policies, personnel, finance, public relations, and other general problems of his organization, he may function in a supervisory capacity or as an executive.

For most of these functions, we believe the agricultural engineering curriculum with a specialized option provides the best training.

Preparing an Engineer for Sales Work*

By JOHN GAMMELL

Supervisor of Sales Training, Allis-Chalmers Manufacturing Company, West Allis, Wisconsin

Two thousand years ago the founder of our Christian era and, no doubt, the greatest salesman of all, said that—"He who would be first among you, must be servant of all." We think this is a good motto and a good description of an ideal technical salesman. Another way we look at a technical salesman is to consider him as an itinerate educator—a man who brings the ideas and knowledge of the factory specialist to the operator in the field. This works both ways, too, in that he brings the problems of the field to the design and development specialist at the factory. A technical salesman is an excellent example of free enterprise at its best. If anyone gets an idea anywhere in this land of ours, you can pretty well rest assured that some salesman somewhere will pick it up and see to it that it is developed by whoever has the proper know-how and facilities to do the developing. If the idea or the device doesn't work as well as some other salesman's idea or device, it is dropped. We think this is a wonderful system. We understand that Joe Stalin and the communists don't like salesmen and consider them one of the prime wastes of the capitalist countries. We don't see how there could be a better way of floating ideas and problems around the country than the way we do it.

Now in order that a salesman carry out this function of being a servant to everyone, of being a disseminator of ideas, of being a catalyst between problems and solutions, he has to have some pretty well defined characteristics. One of the most important of these is to be able to talk easily and naturally about the type of things with which he is concerned. The first problem then in the preparing of an engineer for sales work is to see to it that he is ready, willing and able to clearly convey ideas by speaking to either one person, a dozen people, or a thousand people if need be.

Training Program

In working with those who have been selected as having an aptitude for sales, we suggest that they join public speaking clubs, take public speaking courses, and in general be aware of the power of words. We impress upon them that it isn't how much they know that counts in talking to people, or even how much they tell someone, but how much they are able to say that the other men will understand and remember. In other words, you can read an electrical handbook to a man but it doesn't make him an electrical engineer. All of you have had the experience of hearing people talk about technical matters time and again in which not more than 25 or 30% of what was said was understandable during the discussion. It might be marvelous material for a book or a paper, but for a discussion it falls flat.

In addition to encouraging our prospective salesman to join public speaking classes, we have classes of our own

* Presented before the Industrial Engineering Division at the 59th Annual Meeting of the ASEE, June 28, 1951, Michigan State College.

on company time during which period primarily what we do is to have the future salesman talk about machinery and its application, which is our business. We have other students evaluate his presentation and ask him questions and supplement his talk when they feel that he has left out something of importance concerning the problem at hand.

We show motion pictures, sound slide films, models and generally make use of all the sales gadgetry available.

There is a great deal of talking today about the professional attitude or professional approach. There are many facets to this thought but on the purely technical side, I am impressed by an idea put in my mind by one of my associates, which, incidentally, might also illustrate one of the differences between a technician and a professional engineer. When my associate first started to sell, years ago, he told me he used to get a considerable quantity of orders for centrifugal pumps in which someone would ask for a pump to deliver so many gallons of water at such and such a presure. It seemed to him that since we were in business to sell pumps, we should take the order and make the delivery as expeditiously as possible. His boss said no, that in each case he should call the buyer, or, if possible, go out to see him and find out what he really was trying to do. For instance, a man needs so much water at such and such a presure at such and such a time and place in order to perform a certain operation. To start out with, there may be a better way of performing the operation so that he doesn't really need any water at all beyond what he uses at present. Of course, no salesman indicates to a buyer that he doesn't know what he wants but his attitude is that of a man who is genuinely interested in his customer's problems and is dedicated to the idea that there is always a better way of doing things and that he wants to be sure he has the best way.

With further regard to the application, there are such simple factors as—is it going to operate 24 hours a day, 365 days a year at a maximum capacity, or just 5 minutes a day. In the former case, obviously, a very high efficiency unit is needed; in the latter case, efficiency is hardly a point. Is the pump going to be in series with the other operations in the man's plant in such a manner that if this particular pump fails, the plant has to be shut down, or is it in some parallel function? In one case, complete reliability and serviceability are the important features and the man is not apt to be concerned about the economics of a better and more expensive design. The kind of trouble he has had in the past—and everybody always has troubles—is another factor. Nothing lasts forever and nothing is 100% efficient. Anything short of this is, in a way, trouble. In addition, there are the more common types of difficulties such as premature breakdowns, faulty material, excessive wear, etc. Surely any man with a professional mind wants to know how a man's doing the job now and the difficulties he has had in order that he may be in a position to better overcome them. The professional man has an inquiring mind—he wants to know the problem. He wants to get beyond the "how" and get to the "why."

We infiltrate these ideas in the minds of the potential salesmen in classes of a somewhat formal nature in which, as we mentioned above, the prime idea is to have the student talk about our business.

Community Participation

The truly professional technical salesman should have some imagination, some understanding and some interest of the scope of engineering beyond the immediate environments of his job. We encourage our embryonic sales engineer to carefully select a few of the principal technical and professional organizations of his community, become a member of them, and take part in their activities. We suggest to him that he follow magazine articles on such broad engineering

matters as atomic power, guided missiles, the use of new metals such as magnesium, aluminum, titanium, etc. The changes in the steel industry brought on by the depletion of iron ore in Minnesota should be of interest. This matter of steel production brings up a host of topics which should be intriguing to an engineer—such as the South American and Labradorian iron reserves, steel plants on the East and the West Coast, the pros and cons of the St. Lawrence Seaway. The electric power industry is another industry worthy of study. It has had a truly phenomenal growth. We think this growth should be of interest to any engineer since it touches the engineering world in many points. The industrial and population movements such as to the Southwest and the Pacific Coast must needs be of interest to the sales engineer.

Gas turbines, jet propulsion, guided missiles and even such futuristic items as the possibility of rockets to the moon and earth satellite bodies are in the legitimate field in which any sales engineer should be able to carry on a discussion. In short, a sales engineer should be a man of breadth and imagination. If he is the type of man who wants to probe deeply into one subject to the exclusion of others, then he should not be in the sales field. However, sales requires men who are capable of going deeply in different fields in case it is necessary. Their motivations are, however, broadly scientific but not deeply so. A perfectly sound training would develop a man who is quite well informed on one subject and generally acquainted with many.

In this discussion we have talked very little on the details of strictly technical training but, rather, stressed the broader aspects. We have done this because we believe that most educators and trainers are entirely capable of teaching intelligent people any technical subject on which any volume of information has been developed. It is a matter of how much time and attention you have available for the purpose. In our company we spend two years in rotating salesmen to different plants and different departments. Most of them work in 15 to 20 selected locations, travel to 4 plants, undergo about 20 weeks of lectures interspersed with other work, review numerous movies and sound slide films, etc.

In all of our training we are very careful not to give the impression to the trainee that we are running the place like a Prussian Drill Master. We feel that he is a mature individual who has had 16 years of education and that he undoubtedly has some very good opinions of his own concerning how his training should be conducted. We carefully select our sales trainees on the basis of preference, aptitude, intelligence and personality tests together with a series of six to seven interviews. If he shows up as a salesman and, most important of all, if he feels that he has the proper characteristics for it after these tests and interviews, then we are pretty much inclined to feel that he is a good bet. Once a man has gone through this type of a mill, we hope he has the inner confidence of knowing he is in exactly the right field and that he is an outstanding individual with an unusual chance for success in the area in which he has chosen to work.

In choosing the particular training locations, lecture courses, etc., we do not tell him—you take this location or that one—but, rather, we ask him what type of work would best accomplish rounding out his background. We feel that he is in a better position to know his defects than anyone else. We can certainly help him, and we do make suggestions; but it is his life that is being molded and the choices must needs be his. If he makes a mistake and fails, then, of course, it is too bad; but if we make a mistake and ruin his life, it is a tragedy.

To go back to another aspect of sales training, we believe that good salesmanship begins with product knowledge but it doesn't end there. The peculiar problem of the salesman is how to disseminate engineering information effectively to

other people so that it can more greatly contribute to the very good result of better living for all.

Let me close with one more thought. Mr. Emerson, the essayist, more or less said one time that you can't get something for nothing in this world except *the will to do.* There is no magic in preparing engineers for sales work but a lot of ingenuity and hard work does help and *above all you must impart the will to do.*

College Notes

The General Electric Company has established an annual mathematics fellowship program under which secondary school mathematics teachers may take summer courses at **Rensselaer Polytechnic Institute**, it was announced here today. Dr. Livingston W. Houston, president of Rensselaer, said that there will be 50 fellowships awarded to teachers from 12 eastern states and the District of Columbia for a six-week program from July 7 through August 16, 1952. The program is designed to familiarize secondary school mathematics with the applications of mathematics to the various fields of human endeavor. It will be conducted by the Rensselaer faculty in co-operation with General Electric scientists and engineers, he explained.

Awards for the eighth annual **General Electric Science Fellowship** under which high school science teachers attend a specialized summer session at **Union College**, will be made early in 1952, it was announced here today. Dr. Carter Davidson, president of Union, said that 50 fellowships will be awarded to teachers from 13 eastern states and the District of Columbia for a six-week program from June 30 through August 8, 1952. The program, which has graduated some 350 teachers since its inception in 1945, is designed to acquaint participants with new developments in science and to provide a clearer understanding of how scientific principles are applied to industry.

Preparation for Petroleum Geology and Geophysics

By JAMES T. WILSON

Associate Professor, University of Michigan

Introduction

Geology is the study of the earth by all available means. Consequently it uses information and methods from the other sciences—particularly from chemistry, physics and biology. Geophysics is the application of physics to geological problems, and thus is but a phase of geology. However, the training of a professional geophysicist involves such a thorough grounding in physics as to make it a borderline field.

The scope of geology may be visualized by considering the sub-fields into which it is divided. These are: *Petrology and mineralogy,* which are the studies of rocks and minerals; *Physical geology* or the study of the various processes such as erosion and volcanism; *geomorphology,* which is the study of the development of landshapes; *stratigraphy and historical geology,* which deal with rock sequences and the history of the earth; *paleontology,* which being a study of ancient life is closely allied with historical geology; and *economic and engineering geology,* which depend upon all of the other branches. *Geophysics* and its parallel, *geochemistry,* might also be included. *Structural geology* or the study of rock structures resulting from deformation is included here with physical geology although its importance might warrant giving it separate classification.

Professional geologists are likely to classify themselves as petrographers, structural geologists, stratigraphers with leanings towards either paleontology or structure or both, paleontologists, economic geologists, etc.

The list of original member societies of the American Geological Institute gives a further insight into the scope of the science. These are: the Geological Society of America, the Mineralogical Society of America, the Paleontological Society, Society of Vertebrate Paleontology, American Association of Petroleum Geologists, American Institute of Mining and Metallurgical Engineers, Society of Economic Geologists, Society of Economic Paleontologists and Mineralogists, Society of Exploration Geophysicists, the American Geophysical Union, and the Seismological Society of America.

The paragraphs above indicate that geology is a broad field and that an adequately trained geologist must be quite familiar with several cognate sciences. It is evident that petrographers must be well grounded in chemistry and paleontologists in biology. In fact to a large degree the increasing specialization of geologists is an outgrowth of the need for extensive training in related sciences and because of this it is no longer easy for a geologist to be both a paleontologist and petrographer or a geophysicist and a stratigrapher. There are, of course, certain groupings, as stratigraphy and paleontology, petrography and geochemistry, etc.

Petroleum Geology and Geophysics

The petroleum industry is most interested in those phases of geology that will furnish information about the origin and accumulation of petroleum and natural gas. These materials originate in sedimentary rocks and the accumulations

of economic importance form where they have migrated through the rock and become concentrated in the pore spaces of porous permeable reservoir rocks. The accumulations are in so-called "traps" where the arrangement of the reservoir rock and surrounding impervious rocks has led to concentration of the oil and gas. These traps are of two main types—structural resulting from the folding or faulting and stratigraphic where there have been interruptions in the orderly sequence of deposition of sedimentary rocks. Clearly then structural geology and stratigraphy are the important fields of geology for the petroleum industry. Because both paleontology and geophysics offer valuable tools for the unravelling of details of structure and stratigraphy they too find an important place. Petroleum geologists are likely to be either stratigraphers with paleontological or structural leanings, or to be geophysicists. It is rather difficult to be both.

Curricula at the University of Michigan

For a number of years the Geology Department at the University of Michigan has considered a fifth year beyond the Bachelors degree essential for adequate training for a career in geology. This extra year leads normally to a Masters degree. Our department is in the Literary College (as are most geology departments in the United States) and about one-third of the undergraduate course selections must be in non-science courses. I feel that this is to the student's advantage but it is one of the reasons for the fifth year of study. The curricula discussed below assume this extra year of work.

As basic cognate sciences all geology students must have a year each of college chemistry and either college physics or zoology. In addition they must have credit for mathematics through trigonometry. unless their interests are definitely paleontological they are urged to complete a course in calculus. Students whose primary interest is in geophysics must have mathematics at least through differential equations and additional courses in physics or engineering. It is obviously desirable for all students to have additional chemistry, zoology, physics, and mathematics but there is just so much time. A few years ago a symposium on geological training led to the conclusion, when all conferees suggestions were totalled, that about fourteen years of university work would see a student through the courses he needed.

The basic core of geology courses, beyond the beginning ones in geology and mineralogy, includes a semester each of structural geology, petrology, geomorphology, geological map interpretation, paleontology, and introductory geophysics. In addition a summer session at the field station in western Wyoming is required.

Except for those students showing an early interest in a specific field there is little opportunity for any specialization before the fifth year. Any concentration of interest before that time should, in any case, be directed towards the appropriate cognate sciences. The graduate year may show considerable specialization. Petroleum geologists will usually elect a professional course in the subject and, in addition, will take such courses as sedimentation, advanced structural geology, stratigraphic paleontology, micropaleontology, and geophysical prospecting. Geophysicists will take considerably less geology in their year of specialization but will elect additional courses in mathematics, engineering and physics. A thesis is required for the Masters degree and this permits some further concentration of interest.

It is my opinion, and I feel also the opinion of many oil company geologists, that the background of fundamental sciences and basic geology courses is the most important part of a student's training. I have noticed that a student with forty hours of chemistry, physics, and mathematics, and forty hours of geology will get a better job quicker than a student with twenty hours of the basic sciences and sixty hours of geology.

In the News

Annual Meeting of ECPD

Engineers and engineering educators met in Boston's Hotel Statler, October 19 and 20, for an annual report on the status of the engineering profession. The occasion was the 19th annual meeting of the Engineers' Council for Professional Development, with H. S. Rogers, President of the Polytechnic Institute of Brooklyn presiding.

One of the features of the meeting was a session of the training committee featuring six speakers. They reported on various phases of a six-point training program introduced last year by ECPD to aid young engineers in their first five years in the profession. The program, on which the group plans to spend $20,000, a year, proposes guidance to the young engineer for an adequate development plan in six important areas of professional life. The areas are: in-service training; continued college education; community service; professional registration; self appraisal and selected reading. Those speaking on the training panel were: H. P. Hammond, Dean Emeritus, Pennsylvania State College; J. K. Walter, Training Supervisor, West Penn Power Co.; J. C. McKeon, Manager, University Relations, Educational Department, Westinghouse Electric Corp.; K. B. McEachron, Jr., Manager, Technical Education Division, General Electric Co.; C. S. Crouse, Head, Department of Mining and Metallurgical Engineering, University of Kentucky; F. N. Entwisle, Director, Testing and Guidance Division, Newark College of Engineering.

Another panel discussion on engineering guidance, was held under the direction of Willis F. Thompson, chairman of ECPD's guidance committee. This committee has developed a plan to cover the nation with a network of state committees to disseminate information on effective methods for guidance in engineering, and the first part of the panel was devoted to a detailed account of this development. This was followed by a panel discussion on, "The High School's Point of View on Guidance," featuring three educators from the Massachusetts state school system: Frederick A. Small, Principal, School Department, Norwell, Mass.; Thomas D. Ginn, Director of Vocational Guidance, Boston School Committee; Aaron Fink, Guidance Director, School Department, Stoughton, Mass.

Other highlights of the meeting were a dinner address by Eugene W. O'Brien, Vice-President, W. R. C. Smith Publishing Co., who talked on, "What Junior Engineers Find Important," a luncheon talk by Harold B. Richmond, Chairman of the Board of General Radio Co., on, "Observations on Cooperative Course Training as Viewed by a Manufacturer," and a Saturday luncheon talk by James Rhyne Killian, Jr., President, Massachusetts Institute of Technology.

Additional reports of committees included—education, recognition, information, ethics, and unity in the engineering profession.

The national organizations comprising ECPD are: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Chemical Engineers, National Council of State Boards of Engineering Examiners, American Institute of Electrical Engineers, and The Engineering Institute of Canada.

Minutes of the Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Wednesday, November 14, 1951, at the Rice Hotel, Houston, Texas. Those present were: S. C. Hollister, *President*, M. M. Boring, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, and B. Bowen.

Report of the Secretary

The Secretary presented a written progress report on the current projects and developments of the Society. This is summarized in the Minutes of the General Council meeting of November 14, 1951.

Report of the Treasurer

The Executive Board reviewed the final audit of the Society. The audit showed a net loss of $311.07. By previous action of the Executive Board an amount of $1,315.03 was transferred from the ECRC Reserve and $1,486.45 was transferred from the Special Projects Reserve to defray part of the cost of printing the ECRC *Directory of Research*. When these adjustments were made, the income and expense statement showed a net balance of $2,490.41, which was transferred to the general surplus of the Society.

The financial statement as of November 7, 1951 showed that receipts and disbursements were in line with those of the corresponding period for 1950.

The Treasurer and Secretary presented graphs showing the trend of income and expense over a ten year period. The following is a tabulation of the comparative income and expense for the years 1940–41 through 1950–51.

	1940–41	*1950–51*	*Per cent Increase*
INCOME			
Total income	$20,231.62	$60,317.02	295%
Dues of members	16,994.36	39,113.20	230%
Advertising	2,503.51	9,401.38	370%
EXPENSE			
Total expense	$18,686.28	$60,628.09	325%
Cost of publications	7,002.72	24,139.43	345%
Office salaries and clerical assistance	6,000.00	11,018.44	180%
Office expense and travel	2,001.97	8,117.63	400%
ECAC, ECRC, conferences and meetings, etc.	3,681.59	17,352.59	472%

The following conclusions are to be drawn:

1. The vigorous membership campaign during the past five years has practically doubled the number of individual members in the Society. The increased revenue resulting from this expansion of Society membership has succeeded in keeping income in line with rapidly rising costs.

2. The advertising revenue has increased substantially, partly due to new advertising contracts and partly due to increased rates and volume.

3. It seems evident that the Society cannot anticipate in the future the large increement of new members each year which was experienced during the past five years. The reason is that declining enrollments in engineering colleges are causing a shrinkage of engineering faculty members. There are certain areas of potential membership which offer promising possibilities. These include: (a) industrial members, (b) younger faculty members of instructor and assistant professor rank, and (c) faculty members in junior colleges and technical institutes. An effort will be made this year to expand the membership in these ranks.

4. One of the promising areas of increased Society participation and revenue is that of Associate Institutional members, from among industries of the country. A Committee is being formed, under the chairmanship of Jesse McKeon, Westinghouse Electric Company, to solicit Associate Institutional memberships in the ASEE.

5. The increase in expense is due to: (a) the increased scope of activities of the Society, (b) the enlarged membership, and (c) inflationary costs. The principal single item of expense is the cost of publication of the JOURNAL, which has tripled in ten years.

The Executive Board authorized the Secretary and Treasurer to make a projected study of the Society finances for the next five years, based upon proposals to enlarge the Secretary's office.

Adequacy and Standards of Engineering Education

President Hollister proposed that the various curricular Committees and Divisions of the ASEE conduct a critical investigation of the adequacy and standards of the engineering curricula, with a view to projecting the thinking into the needs of the engineering profession in the years ahead. Major stress would be given to those elements of the curriculum which give continuous and lasting support to the graduate's professional life. Particular attention should be devoted to an inquiry into the adequacy of the scientific foundation in the engineering curricula.

It was recommended that this study enable the engineering colleges to participate actively in the study of their curricula and the extent to which these are meeting the professional needs of the graduate. It was proposed that a national committee be appointed to coordinate the program and provide stimulation and direction.

It was voted to appoint a committee of the ASEE to implement the program on evaluation of the adequacy and standards of engineering education.

Program of Cooperation with Secondary Schools and Junior Colleges

Vice President Boring reported that the meeting of the Upper New York Section of the ASEE was devoted to education and utilization of engineering manpower. This included discussions of the problems from the view point of secondary schools and junior colleges. The panel discussion was transcribed and has been sent to ASEE Section chairmen in the hopes of stimulating similar programs in other Sections.

Mr. Boring also reported that the Edison Foundation is sponsoring and financing a program in which selected secondary school teachers are invited to attend conferences for the purpose of discussing ways and means of strengthening scientific education in the secondary schools.

Vice President Boring suggested that the program of establishing cooperative working relationships with secondary schools and junior colleges be carried directly to the Sections and that they in turn develop methods of implementing these relationships on a regional basis. He stated that a relatively small national committee might be used to coordinate the activities of the local groups.

Report of the Committee on Improvement of Teaching

Vice President Grinter stated that a first draft of the report of the Committee on Improvement of Teaching had been submitted to the Committee members for criticisms and that it was hoped that the final report would be completed during the year.

The Board voted to authorize the Committee on Improvement of Teaching an appropriation of $750 for the preparation of the final report.

Plans for the Annual Meeting

The Board decided to hold general sessions at the Annual Meeting on Tuesday, Wednesday, and Thursday mornings. One morning would be devoted to a general session of the Society as a whole and the other two mornings would be devoted to general sessions sponsored by the ECAC and ECRC.

Secretary Bronwell reported that Dartmouth has adequate housing facilities for up to 2200 persons. This seems ample in view of the attendance of previous ASEE Annual Meetings. The local committees have been appointed and are drawing up plans for the Annual Meeting.

Enlargement of ASEE Headquarters Staff

President Hollister reported that he felt that the Society should be exerting more influence on the pressing national problems bearing on engineering education. To take

on this responsibility involves increased contact with governmental organizations and industry. With the increased responsibility of the Society, it will be necessary to increase the headquarters staff of the ASEE in order to relieve the Secretary of some of the routine work and free him for more important contact work.

Up to the present time, the Secretary's office has employed the Secretary on a part-time basis and two full time office secretaries. This seems inadequate for a national society of over 7000 members, since the Secretary's office is required to: (a) take an active part in the administration of the major projects of the Society, (b) coordinate activities of the Committees, Divisions, Sections, and Councils of the Society, (c) edit the papers for the Journal and handle the advertising, (d) make arrangements for the various meetings of the Society, including the Annual Meeting, (3) be responsible for all receipts and disbursements, including the annual audit, and (f) service the Society membership, including information requested, dues notices and receipts, etc.

The Board recommended the addition of a part-time assistant to the Secretarial staff to take on some of the editorial and other responsibilities. In order to enable the Secretary to enlarge upon his outside contact work, the Board

Voted to authorize an increase in Secretarial travel funds not to exceed $1000 for the current fiscal year.

Applications for Institutional Membership

The following applications were approved for institutional membership in the ASEE: University of Mississippi (active); St. Louis University (active); Lowell Textile Institute (active); University of Omaha (affiliate).

Request of Civil Engineering Division for Summer School in 1952

The Secretary read a letter from Professor Gaylord, Chairman of the Division of Civil Engineering, requesting the Executive Board to approve two summer schools, one in Surveying and Mapping and the other in Sanitary Engineering.

It was voted to authorize ASEE sponsorship of a summer school in Surveying and Mapping and another in Sanitary Engineering, subject to the Civil Engineering Division's desire to sponsor these summer schools. The matter was referred to Dr. Grinter to work out the details with the Civil Engineering Division.

Other Business

The following items of business were discussed at the Executive Board meeting and recommendations are embodied in the Minutes of the General Council meeting of November 14, 1951.

(a) Report of the Teaching Aids Committee.
(b) Formation of a Public Relations Committee.
(c) Committee on Contract Relations with the Federal Government.
(d) Participation in UNESCO.
(e) Associate institutional membership drive.
(f) Mid-year meetings of ASEE Divisions.

Respectfully submitted,

ARTHUR B. BRONWELL,
Secretary

Minutes of General Council Meeting

A meeting of the General Council of The American Society for Engineering Education was held on Wednesday, November 14, 1951, at the Rice Hotel, Houston, Texas. Those present were President S. C. Hollister, M. M. Boring, A. B. Bronwell, L. E. Grinter, G. A. Rosselot, C. L. Skelley, W. L. Everitt, F. M. Dawson, T. Saville, H. W. Barlow, E. R. Jones, W. W. Dornberger, D. C. Hunt, W. E. Street, C. A. Brown, K. McEachron, E. R. Stapley, L. G. Miller, K. Wendt, W. H. Carson, and B. Bowen. The meeting was called to order at 7:00 P.M.

Report of the Secretary

The Secretary presented a progress report which summarized some of the current developments of the Society. These included the following:

(a) A Public Relations Committee, under the chairmanship of Professor Richard Schmelzer of Rensselaer Polytechnic Institute, has been appointed to develop a public relations program for ASEE. It is suggested that all information of interest to the public be channeled through this Public Relations Committee for press releases.

(b) Steps are being taken to form a Committee on Textile Engineering in the ASEE.

(c) Dean Lassalle, chairman of the ECAC Committee on International Relations, is endeavoring to obtain active participation of the ASEE in UNESCO. The area of engineering education is the most conspicuous void in the program of UNESCO and, in view of the fact that the international program of the U. S. government calls for substantial technical assistance to foreign countries, it would seem that engineering education should play an important role.

(d) A committee of the Society has been appointed, under the chairmanship of Jesse McKeon, to increase the number of Associate Institutional memberships.

(e) Several Divisions of the Society are planning mid-year meetings. The Cooperative Engineering Division held a meeting at Northwestern University on November 8–10, 1951. The Engineering Drawing Division is planning a meeting in New York on January 23–25, 1952. The Division on Relations with Industry is planning a meeting to be held at MIT on the theme "The Student as an Individual" on February 2, 1952.

(f) The Secretary reported on the Mission on Engineering Education to Japan. This item was summarized in the Minutes of the Executive Board meeting of October 29, 1951, published in the November issue of the JOURNAL OF ENGINEERING EDUCATION, page 185.

(g) The Secretary presented a written progress report from the Teaching Aids Committee. This Committee has appointed reviewing committees which are starting to review teaching aids. Ultimately a bulletin will be published, listing those teaching aids which are considered to be acceptable for engineering instruction. He reported that the evaluation program is causing companies which are planning teaching aids to seek the advice of engineering teachers in the preparation of their teaching aids. This is a collateral benefit which the Committee had hoped to achieve and which would result in substantial improvement in the quality of teaching aids constructed in the future.

Report of the Treasurer

Copies of the final audit and the comparative statement of receipts and disbursements for the period July 1 to November 7 for 1950 and 1951 were presented by the Treasurer. This is reported in the Minutes of the Executive Board meeting, November 14, 1951.

Adequacy and Standards of Engineering Education

President Hollister reported that a committee of ECPD on adequacy and standards of engineering education has made a study of the engineering curricula. This study indicates that some of the older curricular areas have not advanced significantly in the past 40 years, despite the rapid advancement of science and engineering practice. The

committee report also stated that the engineering curricula are not breaching the gap between the fundamental sciences and engineering instruction. The report stated that there is very little difference in curricular subjects of various schools, but the distinguishing characteristics lie in the depth of instruction and in the objectives in respect to the outlook to be achieved. There exists a spectrum of objectives ranging from highly professional programs supported by strong science backgrounds to vocational programs in which only a moderate amount of science is included.

The ECPD committee recommended that a study be undertaken by the ASEE on this subject. In order to carry out this recommendation, President Hollister has written to chairmen of Divisions and Committees of the Society urging them to give attention to an evaluation of the engineering curricula. It is believed that this activity should be undertaken on a Division and institutional level, with a national committee appointed to coordinate and review the programs and findings of the Division and institutional committees. This will constitute one of the principal programs of the Society for the coming year.

Cooperation with High Schools and Junior Colleges

President Hollister proposed that a program be undertaken on a regional level to develop closer working relationships between secondary schools and the engineering colleges. This program would endeavor to: (a) seek an improvement in the quality of education of students entering engineering colleges, (b) discuss with high school and junior college teachers curricular problems, with particular emphasis upon improvement of the teaching of mathematics and the sciences, (c) provide a means of channeling information to the high school principals, teachers, and counselors on the career opportunities for students in the engineering field.

President Hollister emphasized that this program should focus attention upon the educational preparation of the student and not upon educational philosophy in general. This would avoid controversies which might arise in dealing with the nebulous subject of educational philosophy. It was suggested that this program be undertaken by the Sections of the ASEE, with a central committee of the ASEE coordinating the work of the Sections and exchanging information on methods and results. The Sections would be responsible for stimulating conferences and meetings between engineering colleges in their geographical area and high schools and junior colleges.

Committee on Improvement of Teaching

Vice President Grinter summarized the work of the Committee, stating that after the final report has been made the work of the Committee would be transferred to the Division of Educational Methods. This would be a permanent organization for stimulating continuous improvement. The report should be out in time for the Annual Meeting.

Plans for Annual Meeting

The Secretary presented a brief report of the recommendations of the Executive Board relating to the plan for general sessions at the Annual Meeting at Dartmouth, as described in the Minutes of the Executive Board meeting of November 14, 1951. The Secretary also stated that he has urged the Divisions and Committees to submit their complete program information by the first of February, since a considerable amount of liaison work is necessary with the host institution in assigning rooms and also in eliminating conflicts before the preliminary program can be sent to the printer.

The local committees at Dartmouth have been appointed and are drawing up plans for the Annual Meeting.

Report of Coordinating Committee on Relations with the Government

Dean Saville reported that a committee of the EJC had been appointed to advise the National Science Foundation on problems relating to grants in the engineering field. He also stated that Dean Potter is the only active engineering representative on the National Science Foundation Board and that it is extremely important that he be re-appointed on expiration of his term in May 1952. The General Council recommended to Vice President Rosselot that he get the endorsement of the ECRC for Dean Potter's re-appointment and send this to either Mr. Steelman or Mr. Dawson in the White House.

Dean Saville reported that the UMT bill has been given preferential status in Congress and will be discussed within 60 days of the convening of Congress. The Engineering Manpower Commission will probably testify on this bill.

Unity of the Profession

Dean Saville reported to the Council that a great majority of the societies had balloted on the Unity organization, with the largest majority voting for Plan A. The framework of this organization will be a modification of the EJC, details of the organization to be worked out at a later time.

Contract Relations with the Federal Government

Vice President Rosselot reported that the Committee of the ECRC on Contract Relations with the Federal Government, under the chairmanship of Dr. Raymond Woodrow of Princeton University, is endeavoring to get agreement of various government agencies on uniform provisions in research contracts. He stated that difficulties had been encountered by engineering colleges due to the fact that some government agencies were citing special cases of types of contracts and endeavoring to force the same provisions upon other universities. Dr. Woodrow presented a paper on this subject at the Houston meeting of the ASEE.

Summer Schools

The Executive Board has voted to authorize ASEE sponsorship of summer schools proposed by the Electrical Engineering Division, the English Division, and the Civil Engineering Division. The Civil Engineering Division is proposing a summer school in Surveying and Mapping and possibly another on Sanitary Engineering.

Previously the Executive Board had authorized ASEE sponsorship of a summer school proposed by the General Electric Company to demonstrate some of the more successful methods of instruction used in their advanced engineering training program. This program embodies some of the principal recommendations of the Committee on Improvement of Teaching, and the General Council therefore voted that the summer school be sponsored by the Committee on Improvement of Teaching, in cooperation with the General Electric Company.

Enlargement of Secretary's Office

President Hollister reported that steps are being taken to enlarge the Secretary's staff in order to relieve the Secretary of some of the routine work and free part of his time for more important contact work with other engineering and educational societies, governmental agencies, and industry. The following steps will be directed toward this objective:

(a) A study will be made by the Secretary and Treasurer of the projected finances, based upon an enlarged Secretarial staff.

(b) An assistant secretary will be added to the Secretarial staff on a part-time basis to handle the editorial work on the Journal and other Secretarial responsibilities.

(c) The Executive Board has voted an increase of up to $1000 to the Secretary's travel fund, to enable him to attend important meetings and enlarge the contact work with other organizations and government agencies.

(d) The officers are looking ahead to a full-time secretarial appointment instead of a part-time appointment as in the past.

(e) It is anticipated that the expansion of the Associate Institutional memberships in the Society will defray part of the expense of this change.

Committee of General Council to Report on Activities of the Council

A Committee of the General Council, consisting of H. W. Barlow, Chairman, Eric Walker and L. G. Miller, was appointed to prepare recommendations on methods of expanding the activities of the General Council. The General Council has been largely a policy decision body, which acts upon proposals submitted by Divisions and Committees of the Society or individuals. It has been suggested that the Council members could take a more direct part in the operations of the Society.

Resolution of the Engineering Drawing Division

Professor Street, representing the Engineering Drawing Division, presented a resolution of the Engineering Drawing Division. This resolution was addressed to the Executive Board of the ASEE and proposed that the Executive Board forward it to the Committee on Engineering Schools of the ECPD. It recommended in effect, that in view of the importance of engineering drawing in the

engineering curricula, that ECPD visitation committees should seek the assistance of competent drawing teachers in evaluating the quality of instruction in engineering drawing for engineering curricula accreditation purposes. Dean Dawson moved that the resolution be referred to the Executive Board for study and report back to the Council. The motion was passed.

Life Memberships

The following were voted to life membership in the Society: H. L. Creek, C. H. Mathewson, L. Mitchell, B. J. Robertson, E. J. Streubel, W. C. Taylor, K. O. Thompson.

Respectfully submitted,
ARTHUR BRONWELL
Secretary

College Notes

William Gardner Van Note was installed as the ninth president of **Clarkson College of Technology.** Dr. Van Note was formerly at North Carolina State University at Raleigh.

Charles W. MacGregor, professor of applied mechanics and head of the materials division at Massachusetts Institute of Technology, has been named vice-president of the **University of Pennsylvania** in charge of engineering and scientific studies, President Harold E. Stassen of the University announced last night. In the office at Pennsylvania, newly-created by the trustees, Dr. MacGregor will have jurisdiction over the engineering and scientific departments of the University. His administration will also include the Towne Scientific School and the Moore School of Electrical Engineering.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State College	April 18–19, 1952	E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oncken, Jr., Bureau of Ordnance
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Washington	May 23–24, 1952	T. H. Campbell, University of Washington
Pacific Southwest	University of Nevada	Dec. 27–28, 1951	S. F. Duncan, University of Southern California
*Rocky Mountain	University of Wyoming		E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952.	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

In the News

ASEE Solicits Teaching Aids

The American Society for Engineering Education is issuing a call to industry, the professional societies, public or private research organizations, and the engineering colleges for teaching aids which may be reviewed in its forthcoming "Catalog of Teaching Aids." This publication, which is being prepared by the Society through its Committee on Teaching Aids, will contain reviews of all kinds of teaching aids suitable for use in the teaching of various engineering subjects. The first edition of the catalog will be limited to civil, electrical, and mechanical engineering, mathematics, and engineering mechanics. This edition will also be limited to motion picture films (sound and silent), slides in 2×2 in. or $3\frac{1}{4} \times 4$ in. size, models, charts, and exhibits. Information on such devices should be sent to Professor Carl W. Muhlenbruch, Chairman ASEE Committee on Teaching Aids, Northwestern Technological Institute, Evanston, Illinois, who will see that they reach the proper reviewing group. Each offer of a teaching aid should be accompanied by a written description or photograph and a set of operating instructions.

The chief purpose of the ASEE "Catalog of Teaching Aids" will be to help the engineering teacher choose those teaching aids which most suit his particular needs and to provide him with the assurance that they have been passed upon by competent individuals. The catalog, which is to be sold at a nominal price, will include a brief description of each teaching aid and a review prepared by a committee of three qualified educators in the field for which it is intended. The listing will also indicate where the device may be obtained, its dimensions, important physical characteristics, any charge for its use, and other detail information which the prospective user would require.

It is expected that the catalog will show industry what engineering educators want in the way of teaching aids. Any organization setting out to make teaching aids will have only to study the reviews contained in the catalog to learn what type of teaching aids the colleges need. It can then use this information as a basis for planning its own contributions to the field. The Committee asks that teaching aids, not "training aids," be submitted for review in the catalog. The training aid has its uses in teaching workers in industry how to perform certain manual operations, but in educating engineers it is necessary to provide the student with an understanding of the fundamentals of the subject being studied. For this reason the training aid is not applicable to engineering education. Instead, what is needed are teaching aids, which enable the student to grasp more quickly the fundamentals of the science of engineering and then to apply them to the solution of actual problems.

At the same time, it is necessary that the teaching aid do more than entertain or just use up time. In order to be really effective, teaching aids must encourage and help the student carry out the learning process himself. A teaching aid must perform either of two important services. The first of these is to enable the teacher to present information more rapidly and thoroughly than could be done without the device. An example of this would be a set of color slides on the steel making process. If it is not possible to take the students on an actual tour of a steel mill, this photographic presentation will convey a fuller picture and will require less time than would any word description the instructor might give. The other important function of the teaching aid is to help the student understand a process which could not be presented adequately in another way. Thus the "time microscope," or high-speed motion picture, is a valuable aid in analyzing the action of high speed machinery or the phenomena of cavitation.

National Science Foundation News

Graduate Fellowships in Science

Approximately 400 graduate fellowships will be awarded by the National Science Foundation for the academic year 1952–53 in the mathematical, physical, medical, biological and engineering sciences. Fellows may elect to receive training in fields which combine two or more of these sciences, such as medical physics or physical anthropology. No awards will be made for study in clinical medicine, although applications will be considered from medical students who wish to prepare for careers in medical research.

The majority of National Science Foundation Fellowships will be given to predoctoral applicants, particularly to those who will be eligible to begin graduate study during the coming year. Predoctoral Fellows will be selected on the basis of ability, determined by means of scores made on tests of scientific aptitude and achievement, academic records, and recommendations regarding each candidate's abilities. The testing and evaluation of applicants will be carried on by the National Research Council. Final selection will be made by the National Science Board of the National Science Foundation. A limited number of postdoctoral Fellowships will also be awarded.

Application forms for National Science Foundation Graduate Fellowships are available from the Fellowship Office, National Research Council, Washington 25, D. C. In order to be considered for the 1952–53 academic year, completed applications must be returned to the Fellowship Office, National Research Council, by January 7, 1952. The affidavit and loyalty oath required by the National Science Foundation Act of 1950 will constitute part of the application form and must be completed and returned with other application materials.

New Chairman

Chester I. Barnard, president of the Rockefeller Foundation, was elected chairman of the **National Science Board of the National Science Foundation** at its second annual meeting. Mr. Barnard succeeds James B. Conant, president of Harvard University, who was the first chairman of the Board, elected to serve the initial term. Edwin B. Fred, president of the University of Wisconsin, was re-elected vice chairman of the National Science Board. The new chairman and vice chairman were elected for two-year terms of office as prescribed by the National Science Foundation Act of 1950. Four members of the Executive Committee, whose terms had expired, were also re-elected. These were: Mr. Barnard; Detlev Bronk, president of the Johns Hopkins University and president of the National Academy of Sciences; Lee A. DuBridge, president of the California Institute of Technology; and Elvin C. Stakman, chief of the Division of Plant Pathology and Botany at the University of Minnesota.

Research Proposals

The first draft of a guide to assist scientific research investigators in the preparation of proposals for National Science Foundation research grants has been issued by the Foundation. Copies of the guide will be distributed widely to universities and colleges, laboratories, and other organizations in a position to carry on competent scientific research. The Foundation will support basic research in

the mathematical, physical, medical, biological and engineering sciences, by making grants for such research to educational, industrial, governmental or other institutions, or individuals. Ordinarily grants will be awarded to institutions for research by specified individuals. In reviewing proposals the Foundation will emphasize the scientific merit of the suggested research, including the competence of the scientist under whom the study will be made.

Summer Schools

The Executive Board of the ASEE has authorized sponsorship of summer schools proposed by the Electrical Engineering Division and the English Division. Both summer schools will be held at Dartmouth College preceding the Annual Meeting.

The theme for the Electrical Engineering Division Summer School will be "Undergraduate Teaching of Electrical Circuits and Fields." It will be held on June 20 and 21, 1952, and the registration fee will be $1.50. For further information, address Dr. J. D. Ryder, Electrical Engineering Department, University of Illinois, Urbana, Illinois.

A summer school on Sanitary Engineering has been proposed by the Civil Engineering Division.

New Members

ABBOTT, JOHN P., Dean of Arts and Sciences, Texas A & M College, College Station, Texas. H. W. Barlow, A. B. Bronwell.

ABRAMOWITZ, ABRAHAM, Assistant Professor of Electrical Engineering, City College of New York, New York, N. Y. Harold Wolf, Vincent Deltoro.

BARD, ROBERT E., Associate Professor of Electrical Engineering, Fournier Institute of Technology, Lemont, Ill. J. D. Ryan, A. B. Bronwell.

BATEMAN, RICHARD M., Director, Purdue University Center, Fort Wayne, Indiana. C. W. Beese, Maurice Graney.

BILLINGSLEY, JOHN D., Professor of Ordnance, U. S. Military Academy, West Point, N. Y. O. J. Gatchell, E. R. Heiberg.

BROWN, CHANDLER W., Instructor in Civil Engineering, Duke University, Durham, N. Carolina. W. B. Snow, H. C. Bird.

CAMPBELL, BONHAM, Lecturer in Engineering, University of California, Los Angeles, Calif. L. M. K. Boelter, C. M. Duke.

CARLEY, WILLIAM J., Assistant Professor of Civil Engineering, Clarkson College of Technology, Potsdam, New York. W. H. Allison, L. W. Herron.

CLARK HERBERT M., Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y. P. E. Hemke, R. S. Poor.

DREVDAHL, ELMER R., JR., Assistant Professor of Mining Engineering, South Dakota School of Mines & Technology, Rapid City, S. D. L. E. Shaffer, W. E. Wilson.

DURHAM, FRANKLIN P., Assistant Professor of Aero. Engineering, University of Colorado, Boulder, Colo. K. D. Wood, W. C. DuVall.

EDWARDS, JAMES L., Assistant Professor of Mechanical Engineering, Clemson Agricultural College, Clemson, S. C. D. W. Bradbury, J. E. Shigley.

FUTRAL, SAMUEL M., JR., Instructor in Engineering Drawing, Northwestern University, Evanston, Ill. Raymond Kliphardt, M. B. Lagaard.

GADBOW, VINCENT L., Instructor in English and Social Sciences, South Dakota School of Mines & Tech., Rapid City, S. D. C. M. Rowe, E. E. Clark.

GROGAN, PAUL J., Chairman, Department of Engineering, University Extension Division, University of Wisconsin, Madison, Wisconsin. K. F. Wendt, B. G. Elliott.

HARLEY, JOHN D., Professor of Engineering, A. & I. State University, Nashville, Tenn. B. L. Dutton, W. C. McNeill.

HENDERSON, CHARLES, Dean of Engineering, University of Virginia, Charlottesville, Va. E. C. McClintock, H. L. Kinnier.

HINEBAUGH, MYRON E., Instructor in Electrical Engineering, University of Tennessee, Martin Branch, Martin, Tenn. J. O. Jones, W. C. Taylor, Jr.

IRWIN, HARRY H., Professor of Mathematics, Washington State College, Pullman, Wash. H. F. Lickey, E. G. Ericson.

JONES, DANIEL W. B., Instructor in Civil and Architectural Engineering, University of Colorado, Boulder, Colo. M. W. Jackson, R. E. Rathburn.

KAUFMANN, FRED H., Professor of Economics, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, E. E. Petty.

KEEHNER, JOHN B., Instructor in Physics, Science Dept., General Motors Institute, Flint, Michigan. H. M. Dent, C. A. Brown.

KIRCHNER, JAMES W., Acting Instructor in Electrical Engineering, Ohio University, Athens, Ohio. E. J. Taylor, P. H. Black.

LAPRADE, GEORGE L., Instructor in Science Dept., General Motors Institute, Flint, Mich. H. M. Dent, C. A. Brown.

LINSLEY, RAY K., Associate Professor of Civil Engineering, Stanford University, Stanford, Calif. B. M. Green, E. L. Grant.

LOGAN, LELAND, Instructor in Engineering, Champlain College, State University of New York, Plattsburg, N. Y. S. C. Allen, E. S. B. Litkin.

LYMAN, JOHN R., Instructor in Mechanical Engineering, University of Maine, Orono, Maine, J. F. Lee, A. S. Weaver.

MANCILL, JULIAN D., Professor of Mathematics, University of Alabama, Tusca-

loosa, Ala. (On leave: Redstone Arsenal —in charge of graduate training in engineering—Huntsville, Ala.) H. Kuenzel, C. H. Bryan.

MARTIN, ALLAN E., Assistant Professor of Metallurgy, University of Minnesota, Minneapolis, Minn. R. L. Dodell, H. S. Jerabek.

MARTIN, ARWOOD J., Instructor in Electronics, Wentworth Institute, Boston, Mass. W. C. White, M. N. Anlin.

MCCLAY, CLARENCE H., Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. D. G. Ryan, J. H. Potter.

MILLER, JEANNE I., Editor, Technical Education News, McGraw-Hill Book Company, New York, N. Y. K. L. Holderman, E. E. Booher.

MURPHY, EDWARD P., Management Specialist, Training Dept., A. O. Smith Corporation, Milwaukee, Wis. J. E. Conway, R. J. Panlener.

NEMECEK, IVAN V., Assistant Professor of Mechanical Engineering, University of Kansas, Lawrence, Kansas. L. O. Hanson, A. N. Paul.

PATERSON, ALEXANDER, Associate Professor of Civil Engineering, University of Detroit, Detroit, Mich. H. Gudebski, R. H. McCormack, Elihu Geer.

RICE, HAROLD S., Instructor in Mathematics, Wentworth Institute, Boston, Mass. J. A. Macdonald, C. W. Tudbury.

RIGHTER, KARL E., Instructor in Mathematics, Technical Institute, State University of New York, Buffalo, N. Y. H. A. Panton, R. R. Dry.

ROBERSON, JOHN A., Instructor in Civil Engineering, State College of Washington, Pullman, Washington. C. L. Booker, E. G. Ericson.

SCHEER, ALFRED C., Assistant Professor of Civil Engineering, South Dakota School of Mines and Technology, Rapid City, S. D. G. A. Beebe, E. E. Clark.

SCOTT, KENNETH E., Instructor in Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Mass. B. L. Wellman, G. H. MacCullough.

SINDLINGER, WALTER E., Dean, Orange County Community College, Middletown, N. Y. W. H. Branch, F. E. Almstead.

SKOGLUND, VICTOR J., Assistant Professor, University of New Mexico, Albuquerque, N. Mex. A. D. Ford, M. E. Farris.

STEVENS, CARROL H., Instructor in Physics and Mathematics, Purdue University Extension, Hammond, Ind. A. F. Wilke, H. A. Williamson.

TANGER, GERALD E., Instructor in Engineering, Brown University, Providence, R. I. Z. R. Bliss, P. N. Kistler.

TILLES, SEYMOUR, Assistant Professor of Industrial Engineering, Purdue University, Lafayette, Ind. W. J. Richardson, M. E. Mundel.

VILLAUME, JOHN C., Acting Dean of the Faculty, International Correspondence Schools, Scranton, Pa. E. C. Lawson, Jr., A. B. Bronwell.

VOELKER, MERVIN J., Instructor in Mining, South Dakota School of Mines & Tech., Rapid City, S. D. L. E. Shaffer, W. E. Wilson.

WASIL, BENJAMIN A., Instructor in Civil Engineering, Illinois Institute of Technology, Chicago, Ill. L. E. Grinter, J. G. Duba.

WRIGHT, THOMAS A., Instructor in Engineering Extension Dept., Pennsylvania State College, State College, Pa. V. E. Neilly, K. L. Holderman.

ZIMPFER, WALTER H., Assistant Professor of Civil Engineering, University of Florida, Gainesville, Florida.

ZWIEP, DONALD NELSON, Assistant Professor of Mechanical Engineering, Colorado, A & M College, Fort Collins, Colo. H. Mummert, J. H. Scofield.

265 new members this year

Engineering Enrollments and Degrees, 1951 *

By ROBERT C. STORY and HENRY H. ARMSBY **

The downward trend in engineering enrollment appears to be somewhat checked as the demand for trained engineers becomes more acute. This fall the 148 institutions accredited by the Engineers' Council for Professional Development reported enrollments totalling 147,694.. While this total is 8.4 per cent below last year's total engineering enrollment, it is nevertheless not such a severe drop as is the decrease in the male student population reported by all higher educational institutions, which is almost 11 per cent smaller than in the fall of 1950.

Freshmen engineering enrollment, an even more sensitive indicator of the tenor of the times, is 16.2 per cent greater in the ECPD schools than it was in 1950. This increase is in striking contrast to the general decline of approximately 12 per cent in male students enrolling for the first time in all higher educational institutions. For the first time since the wave of returning veterans swelled the freshmen rolls to a record high in 1946, the freshman class has this year resumed the traditional position as the largest of the four classes. Assuming normal progression, it may be expected that the larger freshman class of this year will reverse the steadily declining trend in the number of engineering graduates four years hence.

The increasing demand for engineering services occasioned by the expansion of defense industries, combined with the steady decline in the number of engineering students and graduates, has created an acute shortage of trained engineers, which will apparently grow progressively more acute for several years to come. For the past two years, the increased demand for engineering graduates has been largely met by the veteran students, who have comprised large segments of the graduating classes of 1949–50 and 1950–51. These men, not being subject to military call, have been able to enter industry immediately upon graduation. However, the supply of veteran graduates is rapidly drying up.

The publicity given to this situation by numerous governmental and private agencies has undoubetdly been a major factor in the relatively small decline in the total number of engineering students and in the increase in engineering freshmen enrollment over last year. Probably Selective Service policies with respect to the deferment of college students have also played a part in these developments. However, it must be remembered that engineering students, like all other college students, are not excused from military service. Rather, some of the better qualified students are deferred to permit completion of college courses. In general, all physically fit graduates will be called to active military duty, either through Selective Service or through membership in ROTC units. This means that fewer and fewer new graduates will be available to take civilian engineering positions over the next several years.

* All engineering data appearing in the text of this report are restricted to ECPD-accredited schools. A report covering all engineering schools, regardless of ECPD accreditation, will shortly be issued by the U. S. Office of Education.

** Of the U. S. Office of Education, Federal Security Agency. Mr. Story is Head, Statistical Services Unit, Research and Statistical Standards Section, and Mr. Armsby is Associate Chief for Engineering Education, Division of Higher Education.

The number of undergraduate engineering students reported this fall by institutions accredited by ECPD was 128,367—a decline of 10.2 per cent from 1950. Graduate enrollment, on the other hand, continued to increase. This fall's total of 16,452 students enrolled as candidates for the master's degree is 5.6 per cent greater than last year's total. The number of students enrolled as candidates for the doctor's degree rose 2.9 per cent to 2,875.

Percentagewise, the number of engineering students enrolled in ECPD accredited schools make up about 7 per cent of all college students enrolled in the fall of 1951. This percentage relationship is approximately the same as in the fall of 1950.

Civil, Electrical, and Mechanical continue as the three undergraduate engineering curricula in which the greatest numbers of students are enrolled. About 56 per cent of all undergraduate engineering students are enrolled in these three curricula—21.1 per cent in mechanical, 19.1 per cent in electrical and 15.4 per cent in civil. There is an increasing tendency on the part of the schools not to assign freshmen to specialized curricula. This fall approximately 13 per cent of all undergraduate engineering students were reported in the "unclassified" category; the bulk of these being freshmen. Two years ago, in the fall of 1949, only 5 per cent were reported as "unclassified."

The increasing desire for graduate training in engineering is reflected by the fact that graduate enrollment is now three times what it was in 1940. At that time, the graduate students comprised only 4.6 per cent of all engineering students. This fall, 13.1 per cent of all engineering students are taking graduate work. For the entire college population, the percentage of graduate students is estimated at about 10 per cent. Almost 28 per cent of all engineering graduate students are taking their training in electrical engineering. Mechanical engineering accounts for about 17 per cent, while approximately 13 per cent are enrolled in chemical engineering

The number of male students who received their undergraduate engineering degrees in 1950–51 is down 21.3 per cent from the previous year. This compares with the decline of 15.3 per cent in first degrees granted to male students in all institutions. Of all first degrees conferred on male students, 13.5 per cent were in engineering.

The 148 institutions accredited by the ECPD conferred during the year ending June 30, 1951, a total of 37,904 bachelor's degrees in engineering, 5134 master's and professional degrees, and 586 doctorates. These constitute 9.9 per cent of all bachelor's degrees conferred by U. S. colleges and universities, 7.9 per cent of all master's degrees, and 8.0 per cent of all doctorates. Last year these percents were 11.1, 8.4, and 7.4, respectively.

The distribution of first degrees among the four principal egineering curricula was as follows: Mechanical engineering, 9609, electrical engineering, 8616, civil, 6473 and chemical, 3614. The number of graduates in each of the four curricula is considerably lower than it was last year. In mechanical engineering, 26.4 per cent fewer graduated than in the previous year. About 30 per cent fewer were graduated in electrical engineering, 11.5 per cent fewer in civil, and 18.3 per cent fewer in chemical.

The data contained in this report are based upon a survey of engineering schools and colleges made in October, 1951, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by the joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education [1] which reported that they conferred degrees in engineering during 1950–51 [2] were requested to supply

[1] Education Directory, Part III, Higher Education, 1950–51.

[2] Earned Degrees Conferred in Higher Educational Institutions, 1950–51, Circular No. 333, U. S. Office of Education.

data. Eight Canadian institutions were also included. Replies were received from all institutions accredited by the ECPD, from 44 other U. S. institutions, and from 7 in Canada.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE general council, the tabulations in this report list individually only the ECPD accredited institutions (eligible for active institutional membership in the ASEE) but contain data for the other U. S. institutions as a group and for the Canadian institutions as a group.

Definition of Items:

Period covered: Engineering schools were asked to report student enrollment as of October 5, 1951. A few institutions, however, because of late opening, were unable to report before late November. Degree data are for the period July 1, 1950 to June 30, 1951.

Undergraduate students: Institutions were requested to report by class level only those students enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) may include degree candidates as well as students who are not working toward a degree.

Graduate students: Institutions were requested to "Report all students who have been admitted to formal graduate standing and are enrolled in graduate courses—regardless of the number of credit hours carried by the students, and regardless of whether the student's work is administered by the engineering college or the graduate school."

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENTS

(for United States only)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Yr.	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	14,079	108,911	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951*	34,147	23,408	24,757	27,820	2,946	15,289	128,367	37,904 (1950–51)

Graduate Enrollment

	Master's Degrees and other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)
1951*	6,878		9,574	16,452	5,134 (1950–51)	2,419		456	2,875	586 (1950–51)

	1940	1947	1948	1949	1950	1951
Total college enrollment in U. S.	1,490,000	2,333,000	2,410,000	2,456,000	2,297,000	2,116,000
Engineering enrollment in U. S.	113,497	244,390	241,554	198,266*	161,324*	147,694*
Per cent engineering to total	7.6%	10.5%	10.0%	8.0%*	7.0%*	7.0%*

* Includes only ECPD accredited institutions.

Undergraduate Engineering Enrollment, by Curricula, October 5, 1951

Engineering Curricula	No. of Schools	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1950–51	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-time Day and Evening Students	Special Day and Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	48	1,173	796	725	743	30	34	217	6	3,177	13	1,087	7
Agricultural	36	374	334	367	426	20	—	1	1	1,522	1	597	1
Architectural	30	821	825	791	884	187	42	49	2	3,576	25	1,016	6
Ceramic	14	117	133	130	180	16	—	5	—	575	6	256	2
Chemical	105	2,647	2,397	2,575	2,809	169	239	603	137	11,533	43	3,595	19
Civil	134	4,178	3,989	4,545	5,118	189	234	1,174	317	19,701	43	6,463	10
Electrical	134	5,107	4,928	5,172	5,931	218	459	2,251	498	24,515	49	8,607	9
Engineering Mechanics	2	—	7	8	23	—	—	—	—	37	1	20	—
Engineering Physics	32	246	341	368	350	32	7	16	6	1,358	8	406	2
General Engineering	27	729	529	562	569	4	—	653	4	3,046	4	848	1
Geological	22	178	235	233	283	5	—	4	—	933	5	308	—
Industrial[1]	60	794	945	1,253	1,583	71	56	304	61	5,057	10	2,253	3
Mechanical	129	5,564	5,411	5,751	6,548	314	532	2,583	431	27,080	54	9,599	10
Metallurgical	46	363	512	568	598	20	28	127	21	2,229	8	795	2
Mining	31	198	286	340	430	4	—	5	4	1,266	1	469	—
Naval Arch. and Marine	4	42	52	52	56	4	—	—	7	213	—	78	—
Petroleum	21	537	565	626	747	6	—	50	3	2,531	3	846	—
Sanitary	7	20	34	29	36	1	—	—	2	121	1	76	—
Textile	5	195	147	137	134	—	—	—	3	616	—	96	—
Unclassified	84	10,390	689	172	26	1	—	5,380	343	16,766	235	70	—
Others	36	474	253	353	346	23	1	2	19	1,463	8	347	—
Total ECPD	148	34,147	23,408	24,757	27,820	1,314	1,632	13,424	1,865	127,849	518	37,832	72
Other U. S. Schools	44	5,424	3,333	2,788	2,902	20	248	2,574	341	17,587	43	3,984	5
All U. S. Schools	192	39,571	26,741	27,545	30,722	1,334	1,880	15,998	2,206	145,436	561	41,816	77
Canadian Schools	7	1,342	1,063	923	1,344	503	29	—	—	5,181	23	1,866	3
Grand Total (U. S. and Canada)	199	40,913	27,804	28,468	32,066	1,837	1,909	15,998	2,206	150,617	584	43,682	80

[1] Includes administrative engineering, management engineering, etc.

Graduate Engineering Enrollment, by Curricula, October 5, 1951

Engineering Curricula	No. of Schools	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1950–51		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1950–51		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1950–51	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Schools accredited by ECPD:																			
Aeronautical	38	369	429	796	2	293	1	46	—	46	—	19	—	108	32	140	—	31	—
Agricultural	19	105	1	106	—	65	—	6	—	6	—	—	—	8	—	8	—	5	—
Architectural	14	45	—	45	—	22	1	—	—	—	—	—	—	—	—	—	—	—	—
Ceramic	13	51	—	51	—	55	—	—	—	—	—	1	—	35	—	35	—	8	—
Chemical	79	836	1,029	1,848	17	736	5	5	—	5	—	2	—	555	68	622	1	174	—
Civil	92	929	900	1,824	5	653	2	17	—	17	—	6	—	177	34	211	—	51	—
Electrical	81	1,577	3,084	4,650	11	1,153	1	56	3	59	—	34	—	521	161	682	—	110	—
Engineering Mechanics	27	123	94	217	—	87	1	2	—	2	—	—	—	100	1	101	—	17	—
Engineering Physics	20	134	219	349	4	35	—	—	—	—	—	—	—	58	—	58	—	12	—
General Engineering	11	166	77	241	2	32	—	—	—	—	—	—	—	41	—	40	1	3	—
Geological	13	76	—	75	1	31	—	—	—	—	—	—	—	13	—	13	—	3	—
Industrial[2]	38	332	1,051	1,382	1	264	3	—	—	—	—	2	—	87	41	128	—	5	—
Mechanical	96	965	1,935	2,898	2	919	1	44	4	48	—	20	—	281	57	337	1	70	—
Metallurgical	39	241	266	503	4	236	—	10	—	10	—	2	—	218	24	242	—	40	—
Mining	21	61	1	62	—	44	—	1	—	1	—	1	—	8	—	8	—	2	—
Naval Arch. & Marine	3	15	1	16	—	11	—	86	—	86	—	34	—	—	—	—	—	1	—
Petroleum	16	111	49	160	—	65	—	—	—	—	—	1	—	5	—	5	—	2	—
Sanitary	15	83	11	94	—	68	—	5	—	5	—	1	—	25	5	30	—	4	—
Textile	4	27	—	27	—	11	—	1	—	1	—	—	—	1	—	1	—	—	—
Unclassified	19	64	253	312	5	44	—	—	—	—	—	—	—	8	—	8	—	16	—
Others	28	284	167	447	4	169	1	5	—	5	—	2	—	170	33	202	1	31	1
Total ECPD	121	6,594	9,567	16,103	58	4,993	16	284	7	291	—	125	—	2,419	456	2,871	4	585	1
Other U. S. Schools	3	205	108	311	2	21	1	—	—	—	—	—	—	—	—	—	—	—	—
All U. S. Schools	124	6,799	9,675	16,414	60	5,014	17	284	7	291	—	125	—	2,419	456	2,871	4	585	1
Canadian Schools	7	147	17	164	—	129	—	20	—	20	—	20	—	44	1	45	—	15	—
Grand Total (U. S. and Canada)	131	6,946	9,692	16,578	60	5,143	17	304	7	311	—	145	—	2,463	457	2,916	4	600	1

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[2] Includes administrative engineering, management engineering, etc.

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[2] Includes administrative engineering, management engineering, etc.

Total Undergraduate Engineering Enrollment, by School, October 5, 1951

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1950–51	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time Day and Evening Students	Special Day and Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited Schools:												
Alabama												
Ala. Poly.	367	278	250	259	—	—	—	—	1,152	2	343	1
Univ. Ala.	157	108	135	158	—	—	491	1	1,045	5	231	1
Arizona												
Univ. Ariz.	195	166	149	169	—	—	—	—	675	4	199	—
Arkansas												
Univ. Ark.	90	77	120	124	—	—	1	1	413	—	159	—
California												
Calif. Tech.	199	58	64	78	—	—	—	—	399	—	79	—
Santa Clara	66	46	61	56	—	—	—	—	229	—	57	—
Stanford	228	119	101	102	—	—	—	—	550	—	198	—
Univ. Calif. (B.)	262	254	530	557	—	—	—	—	1,602	1	790	3
Univ. Calif. (L. A.)	200	167	194	114	—	—	—	—	674	1	178	1
Univ. Southern Calif.	70	126	236	392	—	—	375	—	1,198	1	457	—
Colorado												
Colo. A. & M.	159	97	107	99	—	—	—	—	461	1	109	—
Colo. Mines	134	189	190	243	—	—	—	—	756	—	229	—
Univ. Denver	74	66	84	107	—	6	10	9	355	1	180	1
Univ. Colo.	405	233	284	363	26	—	428	47	1,786	—	517	3
Connecticut												
U. S. Coast Guard	187	146	102	80	—	—	—	—	515	—	63	—
Univ. Conn.	307	166	116	171	—	—	—	—	755	5	171	—
Yale Univ.	—	190	180	208	—	—	—	—	578	—	220	—
Delaware												
Univ. Delaware	105	66	69	96	—	—	—	—	334	2	136	—
Florida												
Univ. Florida	400	275	123	182	—	—	—	3	983	—	257	1
Georgia												
Ga. Tech.	891	598	674	601	40	—	—	—	2,804	—	881	—
Idaho												
Univ. Idaho	165	106	89	90	—	—	—	—	448	2	113	—
Illinois												
Bradley	116	67	73	105	—	8	27	50	445	1	108	—
Ill. Inst. Tech.	270	232	371	475	—	28	3,753	12	4,984	157	691	1
Northwestern	187	168	146	129	—	103	—	34	765	2	161	1
Univ. Ill.	1,141	686	652	622	1	—	—	—	3,096	6	1,003	3
Indiana												
Notre Dame	440	241	238	191	—	—	—	—	1,110	—	121	—
Purdue	1,195	628	802	1,096	—	—	—	13	3,719	15	1,461	8
Rose Poly.	92	57	63	75	—	—	3	—	290	—	131	—

Total Undergraduate Engineering Enrollment, by School, October 5, 1951—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1950–51	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time Day and Evening Students	Special Day and Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Iowa												
Iowa St. Coll.	671	411	346	393	—	—	—	—	1,802	19	586	—
St. Univ. Iowa	37	54	95	91	—	—	—	—	277	—	122	—
Kansas												
Kan. St. Coll.	171	153	182	237	—	—	—	—	741	2	366	1
Kan. Univ.	247	168	250	328	—	—	—	—	986	7	363	—
Wichita	118	60	23	24	—	—	204	—	429	—	17	—
Kentucky												
Ky. Univ.	261	197	139	155	—	—	7	2	756	5	288	1
Louisville	101	76	69	99	109	—	—	—	454	—	44	—
Louisiana												
Louisiana Poly.	207	55	77	81	—	—	—	4	423	1	122	1
Louisiana St. Univ.	407	138	197	268	—	—	—	—	1,007	3	293	2
Tulane Univ.	138	88	75	59	—	—	5	—	364	1	104	—
Maine												
Univ. Maine	211	155	147	170	—	—	—	4	687	—	251	2
Maryland												
Johns Hopkins	134	160	118	93	—	—	—	—	505	—	127	—
Md. Univ.	308	152	160	198	1	—	—	13	831	1	248	—
U. S. Naval PG Sch.	—	—	196	134	—	—	—	—	330	—	149	—
Massachusetts												
Harvard	32	6	26	29	—	—	—	—	93	—	18	—
Lowell Textile	52	60	46	48	—	—	—	3	209	—	41	—
Mass. Inst. Tech.	556	524	582	693	4	—	—	—	2,344	15	799	3
Mass. Univ.	208	88	65	97	—	—	—	—	456	2	126	—
Northeastern	490	366	331	345	—	425	—	—	1,951	6	336	2
Tufts	167	136	119	105	—	—	—	—	526	1	132	—
Worcester	171	160	165	157	—	—	—	—	653	—	169	—
Michigan												
Detroit Univ.	347	168	219	216	—	344	200	3	1,492	5	522	—
Mich. M. & T.	268	235	230	251	8	—	—	—	989	3	343	—
Mich. St. Coll.	305	186	245	364	—	—	—	—	1,099	1	436	—
Mich. Univ.	355	397	363	559	—	—	—	30	1,692	12	868	1
Wayne Univ.	288	190	269	207	68	—	—	7	1,020	9	156	1

Minnesota												
Minn. Univ.	386	324	276	361	214	—	—	13	1,573	1	752	1
Mississippi												
Miss. St. Col.	99	112	69	116	1	—	—	—	397	—	142	—
Miss. Univ.	53	25	33	47	—	—	94	—	252	—	16	—
Missouri												
Mo. Mines	227	175	307	402	—	—	—	—	1,109	2	602	—
Mo. Univ.	177	128	143	130	—	—	—	—	578	—	254	—
St. Louis Univ.	126	95	86	102	—	—	14	—	420	3	137	—
Wash. Univ. (St. L.)	155	113	156	202	—	—	—	—	622	4	209	—
Montana												
Mont. St. Col.	114	91	80	111	—	—	—	—	396	—	166	—
Mont. Mines	67	40	52	52	—	—	—	1	212	—	56	—
Nebraska												
Nebr. Univ.	224	148	131	151	—	—	15	—	667	2	275	—
Nevada												
Nevada Univ.	58	56	52	54	—	—	—	5	225	—	85	—
New Hampshire												
Dartmouth	123	47	45	20	—	—	—	—	235	—	26	—
New Hamp. Univ.	137	75	80	92	—	—	—	1	383	2	102	—
New Jersey												
Newark	229	256	274	267	—	—	1,066	—	2,078	14	326	2
Princeton	159	119	113	102	—	—	—	2	495	—	105	—
Rutgers	149	95	67	101	—	—	—	1	411	2	152	—
Stevens	214	171	212	186	—	—	—	—	783	—	313	—
New Mexico												
N. Mex. A. & M.	66	60	50	60	—	—	9	2	247	—	96	1
N. Mex. Univ.	172	69	85	113	—	—	47	—	482	4	136	—
New York												
Alfred	70	55	40	53	—	—	5	—	217	6	65	—
Brooklyn Poly.	253	250	305	348	—	—	2,224	—	3,378	2	505	—
Clarkson	248	155	163	250	—	—	—	5	821	—	300	—
City Col. of N. Y.	938	385	386	442	—	—	—	875	3,001	25	531	3
Columbia	—	—	125	116	—	—	—	—	241	—	387	2
Cooper Union	126	99	67	62	—	—	352	—	701	5	106	—
Cornell	438	376	313	248	273	—	—	—	1,639	9	190	1
Manhattan	313	158	136	152	—	—	—	—	759	—	284	—
N. Y. Univ.	241	253	326	356	—	—	1,235	21	2,432	—	497	—
Pratt	54	52	43	72	—	—	—	—	217	4	121	—
Rensselaer	569	547	608	861	—	—	206	11	2,781	21	1,096	4
Rochester	67	37	31	58	—	—	—	—	193	—	57	—
Syracuse	163	109	103	206	—	—	10	3	592	2	376	2
Union Col.	75	59	50	47	—	—	—	—	231	—	82	—
Webb	22	17	14	9	—	—	—	—	62	—	14	—
North Carolina												
Duke Univ.	120	89	81	65	—	—	—	1	356	—	93	—
N. C. St. Col.	461	300	294	380	10	—	—	—	1,442	3	387	—

Total Undergraduate Engineering Enrollment, by School, October 5, 1951—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										No. of First Engineering Degrees Conferred 1950–51	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time Day and Evening Students	Special Day and Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
North Dakota												
N. Dak. Ag. Col.	132	77	73	88	—	—	—	—	370	—	127	—
N. Dak. Univ.	98	51	55	61	—	—	—	—	264	1	91	—
Ohio												
Akron	96	45	37	42	—	48	—	—	266	2	37	—
Cast Inst.	269	260	262	311	—	—	190	—	1,291	1	323	—
Cincinnati	313	229	227	253	—	286	—	—	1,306	2	315	—
Fenn	102	67	73	38	—	113	752	30	1,174	1	193	—
Ohio St. Univ.	492	354	323	305	379	—	230	23	2,101	5	692	3
Ohio Univ.	132	76	79	113	—	—	—	—	399	1	137	—
Toledo	138	87	103	116	—	—	312	—	754	2	167	2
Univ. Dayton	134	40	45	41	—	—	—	—	260	—	73	—
Oklahoma												
Okla. A. & M.	385	201	227	247	33	—	2	—	1,095	—	427	—
Okla. Univ.	357	310	302	510	—	—	1	—	1,470	10	591	—
Tulsa	141	137	131	119	—	—	21	170	708	11	146	—
Oregon												
Oregon State	231	151	167	215	—	—	—	—	764	—	269	—
Pennsylvania												
Bucknell	57	56	68	76	—	—	—	—	255	2	93	1
Carnegie	266	245	238	261	—	—	549	10	1,565	4	280	—
Drexel	380	263	209	201	—	212	—	12	1,271	6	281	2
Lafayette	124	91	125	138	—	—	—	—	478	—	171	—
Lehigh	448	366	339	289	—	—	—	—	1,442	—	314	—
Pa. St. Col.	956	530	470	574	—	—	—	19	2,540	9	597	1
Pittsburgh	274	235	277	321	—	—	339	—	1,442	4	522	1
Swarthmore	29	17	19	23	—	—	—	—	86	2	25	—
Univ. Pa.	114	66	75	120	—	—	—	—	375	—	106	—
Villanova	125	71	83	117	14	—	—	—	410	—	124	—
Rhode Island												
Brown	110	76	36	39	—	—	—	—	259	2	85	1
R. I. University	118	96	92	100	—	—	—	—	404	2	183	—

South Carolina												
Citadel	146	72	48	74	—	—	—	—	340	—	61	—
Clemson	487	234	239	192	—	—	—	—	1,152	—	209	—
S. C. Univ.	136	63	57	69	—	—	—	—	323	2	119	—
South Dakota												
S. Dak. Mines	163	57	85	99	—	—	—	—	403	1	142	—
S. Dak. St. Col.	89	46	56	64	—	—	—	—	253	2	99	—
Tennessee												
Tenn. Univ.	198	165	166	143	—	—	—	—	672	—	318	—
Vanderbilt	172	92	85	69	—	—	—	—	413	5	119	2
Texas												
A. & M. Col. Tex.	986	521	536	388	41	—	16	8	2,496	—	644	—
Rice	147	91	59	63	63	—	—	—	423	—	7	—
Southern Meth.	89	92	39	76	—	59	40	13	408	—	131	—
Tex. Coll. A. & I.	55	36	29	34	—	—	—	—	154	—	46	—
Tex. Tech. Col.	248	169	150	230	—	—	—	—	793	4	235	—
Tex. Western	115	67	61	38	—	—	—	—	281	—	46	—
Tex. Univ.	369	312	443	446	—	—	—	—	1,566	4	421	1
Utah												
Utah Ag. Col.	70	48	56	58	—	—	—	—	232	—	49	—
Utah Univ.	252	132	187	122	—	—	—	—	693	—	180	1
Vermont												
Norwich	124	41	29	46	—	—	—	—	240	—	64	—
Vermont Univ.	71	50	49	39	—	—	—	4	211	2	78	—
Virginia												
Va. Mil. Inst.	215	93	84	89	—	—	—	—	481	—	107	—
Va. Poly.	429	342	280	418	—	—	2	5	1,475	1	638	—
Va. Univ.	102	67	66	85	—	—	—	1	321	—	92	—
Washington												
Wash. St. Col.	186	91	149	161	22	—	—	—	608	1	183	1
Wash. Univ.	494	225	246	272	6	—	—	—	1,241	2	433	1
West Virginia												
W. Va. Univ.	144	142	157	131	—	—	—	—	572	2	281	—
Wisconsin												
Marquette	235	200	168	180	—	—	163	1	947	—	362	—
Univ. Wisconsin	341	251	401	395	—	—	—	357	1,742	3	553	—
Wyoming												
Wyoming Univ.	132	62	65	85	—	—	—	—	342	2	112	—
Dist. of Columbia												
Catholic Univ.	61	61	73	104	—	—	25	—	324	—	205	—
Geo. Wash. Univ.	205	140	106	85	—	—	—	28	559	5	133	1
Howard Univ.	65	25	38	39	—	—	—	—	166	1	44	—
Alaska												
Univ. of Alaska	31	21	12	19	1	—	—	7	89	2	10	—
Hawaii												
Univ. Hawaii	124	70	70	52	—	—	1	—	315	2	41	—
Total ECPD Schools	34,147	23,408	24,577	27,820	1,314	1,632	13,424	1,865	127,849	518	37,832	72

Total Graduate Engineering Enrollment, by School, October 5, 1951

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1950–51		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1950–51		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1950–51	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited Schools:																		
Alabama																		
Ala. Poly	12	—	12	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Ala	13	77	90	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Ariz	28	29	56	1	11	—	—	—	—	—	—	—	1	—	1	—	1	—
Arkansas																		
Univ. Ark	18	—	18	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
California																		
Calif. Tech	92	—	92	—	87	—	50	—	50	—	17	—	66	—	66	—	21	—
Stanford	172	—	172	—	114	—	27	—	27	—	15	—	46	—	46	—	18	—
Univ. Calif. (B.)	171	—	171	—	175	—	12	—	12	—	5	—	67	—	67	—	9	—
Univ. Calif. (L. A.)	149	—	147	2	20	—	—	—	—	—	—	—	38	—	37	1	3	—
Univ. Southern Calif	74	237	311	—	52	—	5	—	5	—	—	—	2	—	2	—	2	—
Colorado																		
Colo. A. & M	19	—	19	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Colo. Mines	76	—	76	—	40	—	—	—	—	—	—	—	17	—	17	—	5	—
Univ. Denver	12	6	18	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Colo	45	147	192	—	45	—	—	—	—	—	4	—	4	—	4	—	2	—
Connecticut																		
Univ. Conn	15	107	122	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ	59	—	58	1	52	—	—	—	—	—	—	—	47	—	47	—	11	—
Delaware																		
Univ. Delaware	21	120	141	—	32	—	—	—	—	—	—	—	16	—	16	—	8	—
Florida																		
Univ. Florida	49	—	49	—	24	—	—	—	—	—	—	—	32	—	32	—	1	—

Georgia																		
Ga. Tech	122	—	122	—	127	—	—	—	—	—	—	—	24	—	24	—	2	—
Idaho																		
Univ. Idaho	13	—	13	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Illinois																		
Bradley	—	14	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Inst. Tech	92	417	508	1	76	—	—	—	—	—	—	—	53	—	52	1	10	—
Northwestern	42	44	86	—	45	—	—	—	—	—	—	—	35	6	41	—	10	—
Univ. Ill.	227	—	225	2	194	—	—	—	—	—	—	—	179	—	179	—	39	—
Indiana																		
Notre Dame	29	—	29	—	10	—	1	—	1	—	—	—	7	—	7	—	—	—
Purdue	270	5	275	—	178	—	—	—	—	—	—	—	99	—	99	—	37	—
Rose Poly	1	1	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa																		
Iowa St. Col	66	—	66	—	68	—	4	—	4	—	—	—	57	1	58	—	9	—
St. Univ. Iowa	43	—	43	—	48	—	—	—	—	—	—	—	37	—	37	—	6	—
Kansas																		
Kan. St. Col	40	—	40	—	30	—	—	—	—	—	—	—	8	—	8	—	—	—
Kan. Univ	19	—	19	—	21	—	—	—	—	—	—	—	2	—	2	—	1	—
Wichita	4	4	8	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
Ky. Univ.	29	—	29	—	19	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisville	14	—	14	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana																		
Louisiana St. Univ	54	—	54	—	26	—	—	—	—	—	—	—	—	—	—	—	3	—
Tulane Univ	16	—	16	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine																		
Univ. Maine	12	—	12	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		
Johns Hopkins	74	57	131	—	45	—	—	—	—	—	—	—	58	3	61	—	8	—
Md. Univ.	268	166	434	—	27	—	—	—	—	—	—	—	21	11	32	—	1	—
U. S. Naval PG Sch	51	—	51	—	42	1	—	—	—	—	—	—	—	—	—	—	—	—
Massachusetts																		
Harvard	60	2	61	1	111	1	6	—	6	—	4	—	76	—	75	1	26	—
Lowell Textile	12	—	12	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech	541	—	539	2	405	1	140	—	140	—	64	—	269	—	269	—	83	—
Mass. Univ	1	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northeastern	—	379	369	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester	14	—	14	—	21	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan																		
Mich. M. & T.	17	—	17	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—
Mich. St. Col	36	—	36	—	33	—	—	—	—	—	—	—	8	—	8	—	2	—
Mich. Univ	260	35	295	—	269	—	—	—	—	—	1	—	114	4	118	—	34	—
Wayne Univ	152	2	152	2	7	—	—	—	—	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 5, 1951—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1950–51		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1950–51		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1950–51	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Minnesota																		
Minn. Univ.	163	67	230	—	104	2	—	3	3	—	1	—	90	—	90	—	15	1
Mississippi																		
Miss. St. Col.	8	—	8	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Miss. Univ.	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Missouri																		
Mo. Mines	63	—	62	1	68	—	—	—	—	—	—	—	12	—	12	—	—	—
Mo. Univ.	26	—	26	—	30	—	—	—	—	—	—	—	8	—	8	—	3	—
St. Louis Univ.	20	86	106	—	1	—	—	—	—	—	—	—	2	—	2	—	—	—
Wash. Univ. (St. L.)	202	—	202	—	32	—	—	—	—	—	—	—	35	—	35	—	7	—
Montana																		
Mont. St. Col.	22	—	22	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Mont. Mines	10	—	10	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska																		
Nebr. Univ.	11	—	11	—	13	1	1	—	1	—	1	—	1	—	1	—	—	—
New Hampshire																		
Dartmouth	22	—	22	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hamp. Univ.	4	—	4	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Newark	—	572	571	1	61	—	—	—	—	—	—	—	—	—	—	—	—	—
Princeton	64	—	64	—	37	—	—	—	—	—	—	—	28	—	28	—	5	—
Rutgers	150	—	146	4	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Stevens	8	1,249	1,251	6	134	2	—	—	—	—	—	—	—	7	7	—	—	—
New Mexico																		
N. Mex. A. & M.	—	28	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Univ.	6	81	87	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
Alfred	12	—	12	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly.	55	1,431	1,483	3	117	2	—	—	—	—	—	—	28	135	163	—	11	—
Clarkson	6	—	6	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
City Col. of N. Y.	—	231	231	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—

New York—*Continued*																		
Columbia	180	263	442	1	281	2	—	—	—	—	—	—	220	—	220	—	20	—
Cornell	64	—	63	1	49	—	—	—	—	—	—	—	54	—	54	—	19	—
N. Y. Univ.	37	720	754	3	145	—	—	—	—	—	—	—	—	164	164	—	9	—
Rensselaer	145	148	291	2	104	—	—	—	—	—	—	—	33	—	33	—	2	—
Rochester	6	—	6	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Syracuse	26	101	126	1	19	—	—	—	—	—	—	—	29	4	33	—	2	—
Union Col.	—	51	51	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Webb	8	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
North Carolina																		
N. C. St. Col.	79	—	79	—	17	1	—	—	—	—	—	—	13	—	12	1	—	—
North Dakota																		
N. Dak. Univ.	2	—	2	—	1	—	—	—	—	—	—	—	2	—	2	—	1	—
Ohio																		
Case Inst.	74	414	482	6	64	1	—	—	—	—	—	—	31	54	85	—	16	—
Cincinnati	18	—	18	—	8	—	—	—	—	—	—	—	10	—	10	—	3	—
Ohio St. Univ.	149	94	243	—	168	—	—	—	—	—	—	—	80	—	80	—	40	—
Ohio Univ.	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Toledo	—	57	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oklahoma																		
Okla. A. & M.	63	62	125	—	51	—	—	3	3	—	2	—	5	—	5	—	—	—
Okla. Univ.	44	—	44	—	29	—	—	—	—	—	—	—	2	—	2	—	2	—
Tulsa	25	21	46	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon																		
Oregon State	20	—	20	—	27	—	—	—	—	—	—	—	2	—	2	—	—	—
Pennsylvania																		
Bucknell	3	—	3	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Carnegie	43	133	165	1	47	—	—	—	—	—	—	—	63	—	63	—	13	—
Drexel	214	—	214	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	29	—	29	—	28	—	—	—	—	—	—	—	23	—	23	—	6	—
Pa. St. Col.	49	—	49	—	50	—	3	—	3	—	9	—	30	—	30	—	12	—
Pittsburgh	33	473	506	—	40	—	—	—	—	—	—	—	7	36	43	—	3	—
Univ. Pa.	70	566	635	1	66	—	—	—	—	—	—	—	38	30	68	—	8	—
Rhode Island																		
Brown	7	8	15	—	2	—	—	—	—	—	—	—	4	1	5	—	1	—
R. I. University	12	—	12	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
South Carolina																		
Clemson	13	—	13	—	5	—	3	—	3	—	—	—	—	—	—	—	—	—
South Dakota																		
S. Dak. Mines	8	—	8	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. Col.	4	—	4	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee																		
Tenn. Univ.	136	—	136	—	22	—	26	—	26	—	—	—	17	—	17	—	1	—
Vanderbilt	2	—	2	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 5, 1951—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1950–51		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1950–51		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1950–51	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Texas																		
A. & M. Col. Tex.	79	—	79	—	49	—	1	—	1	—	1	—	18	—	18	—	4	—
Rice	12	—	12	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Southern Meth.	4	186	190	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Col. A. & I.	5	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Tech. Col.	20	—	16	4	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Univ.	121	—	121	—	81	2	—	—	—	—	—	—	43	—	43	—	5	—
Utah																		
Utah Ag. Col.	7	—	7	—	6	—	2	—	2	—	—	—	1	—	1	—	2	—
Utah Univ.	22	—	22	—	13	—	1	—	1	—	—	—	13	—	13	—	2	—
Vermont																		
Vermont Univ.	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Virginia																		
Va. Poly.	56	—	56	—	61	—	—	—	—	—	—	—	3	—	3	—	2	—
Va. Univ.	11	348	359	—	19	—	—	—	—	—	—	—	—	—	—	—	—	—
Washington																		
Wash. St. Col.	19	—	19	—	8	—	—	—	—	—	1	—	—	—	—	—	—	—
Wash. Univ.	113	91	204	—	60	—	—	—	—	—	—	—	15	—	15	—	2	—
West Virginia																		
W. Va. Univ.	25	—	24	1	28	—	2	1	3	—	—	—	9	—	9	—	—	—
Wisconsin																		
Univ. Wisconsin	58	157	215	—	116	—	—	—	—	—	—	—	67	—	67	—	17	—
Wyoming																		
Wyoming Univ.	19	—	19	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Dist. of Columbia																		
Catholic Univ.	2	77	79	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
Total ECPD Schools	6,594	9,567	16,103	58	4,993	16	284	7	291	—	125	—	2,419	456	2,871	4	585	1

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.

SECTIONS OF THE ASEE *

Active and Affiliate Institutional Members

New England Section

Univ. of Me.
Univ. of Vt.
Norwich
Dartmouth
Univ. of N. H.
Boston and Vicinity:
  Tufts
  Harvard
  Lowell Text. Inst.
  Mass. Inst. of Tech.
  Wentworth Tech. Inst.
  Franklin Tech. Inst.
  Northeastern
Worcester Poly. Inst.
Univ. of Conn.
Brown
Univ. of Mass
Yale
Univ. of R. I.
U. S. Coast Guard Acad.
Bridgeport Engrg. Inst.

Middle Atlantic Section

Stevens Inst. of Tech.
New York and Vicinity:
  College of the City of N. Y.
  Columbia
  Cooper Union
  N. Y. Univ.
  Webb Institute
  Manhattan
  Academy of Aero.
  RCA Institutes
Brooklyn and Vicinity:
  Brooklyn Poly. Inst.
  Pratt Institute
Newark College of Engrg.
Rutgers
Princeton
Lafayette
Lehigh
Philadelphia and Vicinity:
  Drexel Inst. of Tech.
  Univ. of Pa.
Villanova
Swarthmore
Univ. of Dela.

Capitol Section

Johns Hopkins
Univ. of Md.
Washington and Vicinity:
  Catholic
  Howard
  George Washington

Upper New York Section

Clarkson College of Tech.
Rensselaer Poly. Inst.
Union
Syracuse
Cornell
Univ. of Rochester
Alfred
Univ. of Buffalo

Michigan Section

Detroit and Vicinity:
  Univ. of Detroit
  Chrysler Inst. of Engrg.
Wayne
Univ. of Mich.
Mich. State College

Ohio Section

Univ. of Toledo
Sinclair
Ohio Northern
Cincinnati and Vicinity:
  Univ. of Cincinnati
  Ohio Mech. Inst.
Ohio State Univ.
Case Inst. of Tech.
Fenn
Univ. of Akron

Allegheny Section

Pittsburgh and Vicinity:
  Carnegie Inst. of Tech.
  Univ. of Pittsburgh
  Westinghouse Tech. Night School
West Virginia
Pa. State College
Bucknell

Southeastern Section

Univ. of Louisville
Univ. of Ky.
Va. Military Inst.
Univ. of Miss.
Univ. of Tenn.
Va. Poly. Inst.
Univ. of Va.
Duke
N. C. State College
Clemson
Univ. of S. C.
The Citadel
Ga. Inst. of Tech.
Univ. of Fla.
Ala. Poly. Inst.
Tulane
Univ. of Ala.
Louisiana State Univ.
La. Poly. Institute
Southwestern La. Inst.
Miss. State College
Vanderbilt

Missouri Section

St. Louis and Vicinity:
  Washington
  St. Louis Univ.
Univ. of Mo.
Mo. School of Mines
Univ. of Ark.
Ark. Poly. Inst.

* See "What Do You Know About Your Section?" by B. J. Robertson, Jnl. of Engrg. Ed., Feb., 1948.

Illinois-Indiana Section

Northwestern University
Illinois Inst. of Tech.
Univ. of Notre Dame
Purdue
Aero. Univ.
Rose Poly. Inst.
Bradley

North Midwest Section

Mich. College of M. & T.
Marquette
Univ. of Wis.
State Univ. of Iowa
Iowa State College
Univ. of Minn.
Univ. of N. D.
N. D. Agric. College
S. D. State College
S. D. School of Mines
Milwaukee School of Engrg.

Kansas-Nebraska Section

Univ. of Omaha
Univ. of Neb.
Kansas State College
Kansas State Teachers College
Univ. of Kansas

Southwestern Section

Okla. A. & M. College
State Univ. of Okla.
Univ. of Tulsa
Southern Methodist
A. & M. College of Texas
Rice Inst.
Univ. of Texas
Texas College of A. & I.
N. M. College of A. & M.
Univ. of N. M.
Texas Tech. College
Prairie View A. & M.

Rocky Mountain Section

Univ. of Wyo.
Colo. A. & M. College
Univ. of Colo.
Colo. School of Mines
Univ. of Denver

Pacific Northwest Section

Ore. State College
Univ. of Wash.
State College of Wash.
Univ. of Idaho
Mont. School of Mines
Mont. State College

Pacific Southwest Section

Utah State College
Univ. of Utah
Univ. of Ariz.
Calif. Inst. of Tech.
Los Angeles and Vicinity:
  Univ. of Southern Calif.
  Univ. of Calif.
  Cal-Aero Tech. Inst.
  Northrop Aero. Inst.
San Francisco Bay and Vicinity:
  Univ. of Santa Clara
  San Jose State College
  Univ. of Calif.
  U. S. Naval P. G. School
University of Nevada

Unassigned

Univ. of Toronto
Ecole Poly.
Queens
McGill
Univ. of Alaska
Univ. of Hawaii
Univ. of Puerto Rico

The Gift of Engineering*

By L. E. GRINTER
Vice President of the ASEE

In the Beginning only Divine Force could have guided creation of the Universe and the evolution of life on Earth. All creatures endured the forces of nature until the mind of man matured. Then man's desires sought satisfaction by invention of tools to strengthen his hand. But tool making brought civilization with collective cares outreaching the ability of arms even when aided by the lever and wheel. Slowly our forebears began to discover natural laws that explained the drawing of power from falling water, wind and steam. It was only in our fathers' time that electricity on wires, and then on wireless waves encircled the earth, yet *we* have cradled atomic change and released the latent energy that lights the stars, thereby threatening the existence of our enemies and of our own children. It is the engineer's destiny to control and direct power in order to "provide for the common defense, promote the general welfare," and so to help "secure the blessings of liberty to ourselves and our posterity."

As an engineer you are given a favored part in this great design; without you the plan would be less perfect. When you build a bridge, design a dam, perfect a process or link power lines together you play a role in the achievement of human destiny. You therefore owe everything that you have to give in honest and sincere effort toward engineering progress. Dishonesty is inconceivable in even the smallest detail of a professional mission. Carelessness and sloth are but little less reproachable. Integrity and energy deepen the luster placed upon the profession of engineer by the master builders of the past. Disclosure of advances must be given freely to aid in educating the engineers of the future. Thus with each generation rising above the teaching of its forerunner, progress by employment of science is the gift of engineering to mankind. With this gift must go the engineer's unending effort that ethics may mark its use and morality remain its master.

* From an address to Engineering Students.

Dartmouth College

Annual Meeting, ASEE, June 23-27, 1952

When the American Society for Engineering Education visits the Dartmouth campus for its national meeting next June it will be gathering in former Indian territory that retains its tribal character only in the traditions of the college and in the nicknames of the Dartmouth athletic teams.

It was his zeal in carrying his educational and missionary work to the northern tribes that prompted the Rev. Eleazar Wheelock to transport his Indian charity school from Connecticut to Hanover, in the New Hampshire wilderness, and there to plant the seed for one of the nation's oldest and most distinguished institutions of higher learning. The royal charter of Dartmouth College was granted in 1769 by King George III of England, "for the education & instruction of Youth of the Indian Tribes in this Land in reading, writing & all parts of Learning which shall appear necessary and expedient for civilizing and christianizing Children of Pagans as well as in all liberal Arts and Sciences, and also of English Youth and any others." The college, whose founding funds had been raised in England by the Indian Samson Occom, was named for the Second Earl of Dartmouth, its sponsor and benefactor in the mother country.

Dartmouth's educational work has been carried forward without a break for 182 years—a record of continuous operation since its founding that is unique among the American colleges of pre-Revolutionary origin. During that long span of years Dartmouth has held tenaciously to its original character as an undergraduate college of the liberal arts. It is true that it takes pride in three small but excellent graduate schools in medicine, engineering and business administration, but its educational program centers predominantly in the undergraduate college.

"Dartmouth College Case"

Aside from the rugged, rather romantic founding of the college in the wilds of New Hampshire—*Vox Clamantis in Deserto* is the college motto—two events in Dartmouth's history have had particular importance in shaping its present character and quality. The first was the famous "Dartmouth College Case" in which Daniel Webster came to the aid of his alma mater and successfully argued before the U. S. Supreme Court in 1818 that the New Hampshire State Legislature could not violate Dartmouth's charter and transform the college into a state university. This victory for the independent college was the great determining factor in Dartmouth's continuing growth as a liberal arts college; and, indeed, it provided a safeguard for the independence of every private institution in the land.

The other great influence in Dartmouth's history was the leadership of President William Jewett Tucker from 1893 to 1909. It was during this administration that Dartmouth began its real development from a provincial New England college to the national institution it is today. The broad outlines of modern Dartmouth were clearly envisioned by Dr. Tucker, who, although he had been a professor of theology, proved also to be a bold and skillful administrator. The groundwork he laid enabled Dartmouth to enjoy, immediately after World War I, perhaps

the greatest growth and development of any historic college in the country. The long administration of Dr. Ernest Martin Hopkins, from 1916 to 1945, was the perfect complement to the Tucker period in carrying even beyond fruition the plans made at the turn of the century.

Dartmouth's president today is Dr. John Sloan Dickey. He left a distinguished career in law and government service to become head of the college six years ago. He has been intent upon sharpening the college's educational purpose, with emphasis on public-mindedness as a core attribute of the liberally educated man. This sharper focus on useful and intelligent citizenship has been most strikingly embodied in the Great Issues Course, inaugurated in 1947 as a requirement for all seniors. A new Department of Russian Civilization, introduced this fall, has been another important step in relating the liberal arts curriculum to the issues and needs of the modern world.

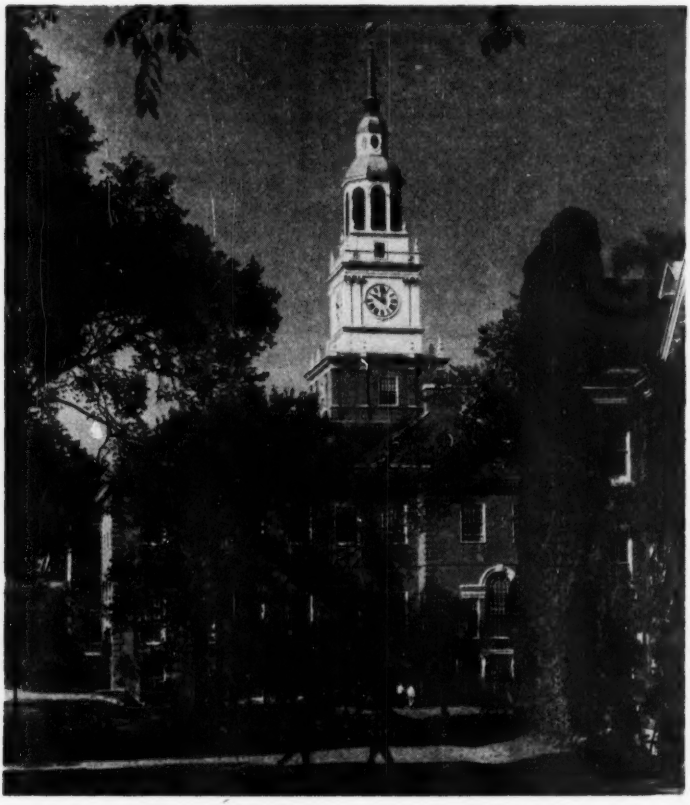
Three Associated Schools

Dartmouth's all-male enrollment this year includes 2,600 undergraduates and approximately 175 graduate students in the three associated schools. Total enrollment in the latter schools is much larger, however, because of the Dartmouth plan of having men begin their engineering, medical and business studies in the senior year. Although it is a New England College, Dartmouth draws two-thirds of its student body from other sections of the country and normally has men from every state. In 1950–51, twenty-six foreign lands were also represented in the student body, which is divided about evenly between men from public and private preparatory schools. The freshman class, varying from 700 to 750 each year, is chosen from an application list of three to four times that number. The admissions plan strives for economic diversity as well as a wide geographic spread, and about one-fourth of Dartmouth students are granted scholarships or other forms of financial aid. The amount of such aid this year will total $422,000.

The Dartmouth faculty of some 300 members is large in comparison with the size of the student body and gives a ratio of teachers to students of about one to nine. Classes average about twenty-two men in size, but one-third of all courses have less than ten men enrolled. Small classes, with close, personal faculty supervision, are especially the rule in the associated schools of engineering, medicine and business administration. Dartmouth faculty members have always enjoyed a rare degree of academic freedom and this is one of the traditions most zealously preserved by the college.

The Dartmouth curriculum is divided into three division: the humanities, the sciences, and the social sciences. Thirty-two different departments are grouped under these three main divisions. In addition to Russian Civilization, two other new departments were added this fall for the work of the Army and the Air Force ROTC Units which have joined the Navy ROTC Unit on the campus. The Dartmouth educational plan prescribes a balanced distribution of courses in the freshman and sophmore years, and allows freedom of election in the last two years, with each student required to major in one field of study and to demonstrate his mastery of that field by passing a comprehensive examination at the end of the senior year. A number of inter-departmental majors are offered, and this year the new Department of Russian Civilization offers the first inter-divisional major in the college's history.

Students of exceptional ability are permitted to set their own educational pace by doing honors work under faculty tutors, and an even greater degree of freedom is given each year to a selected group of Senior Fellows who pursue their studies entirely outside of the regular curricular channels. The only degree awarded by the undergraduate college is that of Bachelor of Arts. The Master's degree is awarded each year to a small number of Teaching Fellows, usually in



Baker Memorial Library, Dartmouth College

the sciences, and in a rare instance a graduate student might receive his Ph.D. at Dartmouth.

The Great Issues Course, now in its fifth year, has attracted wide attention throughout the college world and has provided the pattern for similar courses in at least twenty other institutions. Two features of special interest are the Public Affairs Laboratory in Baker Library and the plan of visiting lecturers whereby authorities of national and international repute are brought to the campus to lecture on each issue and to remain over for a give-and-take discussion with the senior class the next day.

Baker Library, which has a special basement wing devoted to the Public Affairs Laboratory, houses 700,000 volumes and in its scholarly resources outranks the libraries of most of the large universities of the country. When it was completed in 1928 it provided the exceptional center needed for the modern Dartmouth curriculum with its emphasis on individual work and extensive reading in the student's chosen field of study. Baker Library is operated on an informal basis, with an open-stack policy, a Tower Room for recreational reading, and smoking permitted in some of the reading rooms. The walls of the Reserve Room are

decorated with the famous murals by the Mexican artist Orozco. Covering three thousand square feet of wall space, the murals use the Aztec legend of Quetzalcoatl, the Great White Father, to depict the story of civilization on the North American continent.

Baker Library, with its white Colonial spire, dominates the campus. Except for some of the earlier buildings, the Dartmouth plant is of Georgian Colonial design. It spreads out over 175 acres of a plain on the east bank of the Connecticut River, dividing line between New Hampshire and Vermont. The college is excellently equipped in its phyiscal plant of fifty modern buildings, valued at more than ten million dollars. Total assets of the college also include endowment funds of twenty-eight millions.

Winter Sports

The north country location of the college has fostered a distinctive sort of undergraduate life that has led to the widespread associating of Dartmouth's name with outdoor life and winter sports. The major extracurricular activity on the campus is sponsored by the Dartmouth Outing Club, which offers a varied, year-round program that takes advantage of the magnificent natural environment of the college. The club maintains a chain of eighteen cabins and additional shelters, extending from the Vermont hills, just across the river, through the White Mountains to the Dartmouth College Grant of 27,000 acres 140 miles north. Over one hundred miles of mountain trails are also maintained, and at Mt. Moosilauke, called "Dartmouth's Mountain" because the college owns the peak and one whole side, the D.O.C. operates the Moosilauke Ravine Lodge, a huge rustic camp where meals and lodging are available to the public as well as to Dartmouth men. Just this year Dartmouth has inherited from one of her graduates the summit of Mt. Washington, highest point in New England, and the famous cog railroad that runs up one side of the mountain.

The Dartmouth Winter Carnival, a spot of relaxation between semesters every February, is sponsored by the Outing

The Dartmouth College Campus

Club, and so is the Dartmouth ski team, which for many years has been pre-eminent in this increasingly popular sport. The selection of six Dartmouth men for the 1952 U. S. Olympic ski team is striking evidence of the place that skiing holds in Dartmouth's extracurricular life. Nearly every major college acquires some sort of trademark or distinction in the public mind, but it is doubtful if any other institution has ever been accorded virtual ownership of a season as has Dartmouth with respect to winter and the outdoor sports that go with the season of snow and ice.

No description of Dartmouth should close without mention of the nationwide organization of alumni that has become one of the college's greatest assets. One of the pioneer achievements of Dr. Tucker's administration nearly sixty years ago was to assign to the alumni a central and serious role in the work of the college.. On this foundation Datmouth has built steadily and with great success, so that every year more than a thousand graduates serve in official and semi-official capacities, while the rank and file of the 25,000 alumni render a continuing support without which Dartmouth could not have reached its prominent place in American higher education. The work of the alumni has been especially effective in the Selective Process of Admission, under which they handle the entire interviewing job, and in fund-raising. The Dartmouth Alumni Fund this past year raised $577,000 from 15,400 contributors. The percentage of alumni giving to the annual fund—this year's record was 65 per cent of all graduates and non-graduates—gives Dartmouth unchallenged first place in this aspect of alumni support.

The intense loyalty of Dartmouth men is ascribed partly to the north country location of the college, where the comparative isolation, the traditions, the masculine, outdoor life, the concentration in the college itself, all contribute to a unique and lasting spirit. Members of the American Society of Engineering Education, visiting the quiet New England village of Hanover next June, may wonder whether this can all be truly so, but for Dartmouth men everywhere it is one of the certainties of life.

Summer Schools

The Executive Board of the ASEE has authorized sponsorship of summer schools proposed by the Electrical Engineering Division and the English Division. Both summer schools will be held at Dartmouth College preceding the Annual Meeting.

The theme for the Electrical Engineering Division Summer School will be "Undergraduate Teaching of Electrical Circuits and Fields." It will be held on June 20 and 21, 1952, and the registration fee will be $1.50. For further information, address Dr. J. D. Ryder, Electrical Engineering Department, University of Illinois, Urbana, Illinois.

A summer school on Sanitary Engineering has been proposed by the Civil Engineering Division.

"What Type of Training Should Industry Provide for Co-op Engineering Students?"*

By THOMAS HAND

Acting Head, Research Dept., Corhart Refractories Co., Louisville, Ky.

I had the fortunate experience of attending an engineering school that was one of the pioneers in the co-operative plan of education. Having completed the required four years in the "salt mines"—one of the years being devoted to participation in the co-operative plan—I was fortunate in rising to a position with my company, in which I employ and supervise co-operative students from my alma mater.

Unfortunately, all my industrial co-operative work was limited to one company and all my experience in supervising co-op engineering students has been with the same company. Thus, I can not be sure that our own plan will fit other industries.

I can't help thinking back to my school days when my fellow classmates would gather in bull sessions and swap experiences concerning their co-op jobs. At that time—the late 30's—co-op jobs were often considered simply as a source of cheap labor for the Louisville area. Wage rates of 25 cents to 50 cents per hour were common, and the type of work performed was common labor, severely lacking in engineering aspects. This sort of thing was, at that time, quite permissible; shop unionization had not taken place to any major extent. Those were the days when supervisors were a part of the working force, and it was sometimes difficult to draw a line between management and labor.

Today, the pendulum has swung to another extreme. Most labor unions look upon the presence of the co-op engineering student as an infringement upon their private rights; any position held by the co-op student takes bread from the mouth of a union member. This has been a deterrent to the co-op engineering program and has limited its actual use in many training programs. Attempts are now being made by several companies in the Louisville area to correct this fault. My own personal feeling on the subject is that the young engineer misses a lot if he does not have the experience of working with his hands in industry before assuming a more responsible position.

Learning by Doing

There are two views on this problem: First, there is the old school view, which is based upon "learning by doing" and which, incidentally, is the plan usually followed by the engineering school in requiring a student to perform laboratory experiments. I have never found a better training method than the old "do! do! do!, get your hands dirty, dig into the thing, find out what makes it tick" type of thing. Experiences of this sort can never be obtained at a school or office desk. For example, you can read all you want about the operation of a metal cutting lathe, but you'll never know its real use and limitations until you get your hands on

* Presented at the Midwinter Meeting of the Cooperative Education Division, ASEE, at the University of Florida, January, 1951.

one of the things and actually perform the operation

Now, let us consider the other view on the problem. If we are prevented from allowing the co-op engineering student to work in our manufacturing facilities, the only other positions that could offer the essential training are in the laboratories and engineering offices And even the laboratory, in certain industries, comes under the control of the local labor union and is thus eliminated as a training ground. In this respect, we are limited in applying the technique of "learning by doing." Therefore, we must educate our students, by book learning and conference discussion techniques.

In developing a program of co-op engineering training, let us first set down the ideal program; then discuss a practical application of that program

Where do our engineers usually wind up their careers, say 30 or 40 years after graduation from school? It goes without saying that the majority of engineering graduates wind up their careers in executive positions somewhat above the factory supervision level. Thus our training program should be similar to that of executive training and also supply the technical applications of engineering. The two must go hand in hand. If we slight one in favor of the other, we may bend the twig in the wrong direction A balanced program taking into account both these requirements would be ideal. The following program combines engineering training and executive training:

Engineering Training

1. Skills of the Industry
2. Related Training
   a. Math and Shop Problems
   b. Science of the Industry
   c. Blueprint Reading
   d. Product Knowledge
   e. Manufacturing Processes
   f. Maintenance of Equipment
3. Job Methods
4. Safety and Housekeeping
5. Waste Elimination
6. Engineering Economy
7. Research—New Products
8. Research—New Techniques
9. Sales Techniques

Executive Training

1. Human Relations
2. Company Policy
3. Company Morale
4. Job Relations
5. Promotion Opportunities
6. Labor Relations
7. Economics
8. Business Ethics
9. Safety Standards
10. Labor Contracts
11. Law (Corporation and Labor)
12. Forecasting New Developments
13. Research Methods
14. Public Speaking

Subjects in this program have been arranged in the order of their importance. Theoretically, all should be given to an engineer who will eventually hold an executive position. Naturally the two areas should be sandwiched together in outlining the actual program.

To give the co-op engineering student a thorough training in all these subjects in his alloted time would be impossible. As a matter of fact, it requires a lifetime to become proficient in all these phases of management. But I set out to outline an ideal training program and this is it.

Ideal Program in Practical Form

Now, let me take this ideal program and try to fit it into a practical, useful form. In developing a practical program we must first make some assumptions. This program is designed to fit a small to medium-size industry with, say, less than 1000 employees. In industries of larger size there is usually a full-time training program functioning, which can easily be adopted for co-op engineering training. Here, I think, we are concerned with the average company where full-time training programs are not always feasible.

Generally speaking, in smaller industries four departments require some type of engineering skill: Production, Engineering and Maintenance, Development and/or Research, and Sales.

Let us assume that we are going to start with a co-op engineering student who has not yet had any industrial experience and develop a well-rounded program of training for him. This student has probably just finished his basic studies in mathematics, chemistry, and physics. He has been oriented to think of things in scientific terms. He may have an idea that all that is necessary to solve a problem in industry is to set up a mathematical equation or possibly a physics experiment, collect the data, set them into the proper pattern, and get the answer. Problem solved! Next problem. Simple, isn't it? Let's not kid ourselves; I know. I went through that stage, and the majority of students go through the same stage.

Now this could be a definite detriment to co-op training if it is not fully realized and corrected as soon as possible. First impressions are difficult to eradicate. It is not necessarily the fault of the school: these boys have been sitting at a desk for eight hours a day, five or six days a week, for at least one and usually two years. They have had theory, pounded into their heads until it runs out their ears. Then all of a sudden comes a sad awakening: the realization that it's not so easy to apply all these theories to actual problems and make them work as they may have been led to believe by the textbooks and their professors.

Where to Start

Our student is an individual—full of science and extremely anxious to put it to some practical use. Where shall we start him off to lessen his suffering when the light finally dawns?

Looking over the four basic engineering departments, we find that development, control, research, or one of their related components would be the most likely choice. Here would be the department to apply most directly the basic engineering fundamentals in which the student has had his training

A typical first quarter training program might take the following form:

Development—Research—Control
Typical examples:

1. Control work on process or product.
2. Routine testing of product.
3. Physical measurements on new products.
4. Preparation of laboratory samples.
5. Gathering data from experiments.
6. Gathering data from records.

Now that our co-op student is located, we are ready to discuss his duties within the department. This program will have to be quite general, because every industry is different—at least to some degree—in its manufacturing processes. In the majority of laboratories, certain routine control duties in some way reflect their findings toward control of the product or process being carried on or produced in the manufacturing department. This, we feel, is an ideal location to begin a co-op training program. There is usually a simple "cookbook" technique that has been repeated daily for many years We know its limitations from past experience and usually take the results from the control operation with a grain of salt for a short time until our student has mastered the necessary technique. Shortly he will be able to turn in reliable and dependable results.

Another caution we consider important is the choice of the particular student for certain operations. If the control operation is fundamentally based on physics, we normally expect new co-op engineering students from any branch of engineering to perform satisfactorily. However, if the operation happens to be chemical, such as a chemical analysis, we are most cautious whom we might pick to fill the job. In the past, we have noted resentment when we asked mechanical or electrical engineering students to perform chemical operations. This should be avoided in the initial stages, if possible. Let us not forget initial impressions; they may come back to haunt us later.

Along with such control work, we suggest frequent trips into the production

department with a trained man familiar with the process. If meetings are held in the student's department on topics that are of some value—yet not confidential—we find it best to admit the student as an observer. He should not take active part in the discussion until at least his second quarter of co-operative work has been completed.

After one quarter of co-operative work, we feel that the student should be sufficiently oriented in industrial procedure. He no longer needs to be babied but can be given projects not necessarily in his chosen line of engineering. We feel that approximately 75% of the student's time should be spent in performing his regular job and the other 25% should be given over to plant inspection trips, discussion of processes, or problems in the industry.

As for human relations, we do not stress this point too much during the first co-operative period, for two reasons: (1) the student himself is going through a drastic change, and (2) we are also getting acquainted with him and his peculiarities.

During the second quarter of co-operative work, we usually try to acquaint our students with our plant engineering and maintenance departments. If the student is scientifically inclined, we usually allow him advanced training with the development, research, or control departments. A typical program for the second quarter might take the following form:

Plant Engineering and Maintenance
Typical examples:

1. Drafting
2. Plant Layout and Planning
3. Testing of New Equipment
4. Maintenance of Production Equipment
5. Blueprint Checking
6. Simple Equipment Design Problems
7. Bill of Materials for Construction

Development, Research, Control
Typical examples:

1. Research project operator
2. Special development problems
3. Production problems
4. Time Study
5. Patent Research
6. Library Research
7. Construction of Laboratory Equipment

Human Relations Training

During the second quarter, we begin our human relations training. The student is invited to attend supervisor meetings and allowed to become a member of the Company Management Club, which holds monthly dinner meetings away from the plant. The student is given the opportunity to meet the operating staff. His work is so assigned that he must make contact with individuals or groups in order to advance. For example, if the student is assigned to the engineering department, he must make frequent trips into the plant in order to obtain dimensions for drawings of construction projects. Usually he needs some help. He must go to a foreman of the construction or maintenance crew, who in turn assigns one of his men to aid in obtaining the necessary dimensions. In other words, we force the student to make personal contact. If the student is placed on library or patent research work, he must hold frequent discussions with whoever is in charge of the project.

Only rarely is a student allowed to work alone or to lead a project during his second or third co-operative period. However, we have had students—particularly in the electronic field—who were more advanced in their type of work than any of our staff. In such case, we would outline the project, give the required result, and put the student on his own. Meetings are held on each project two or three times a week, and members of the staff are asked to discuss the project with the student. Believe it or not, sometimes the staff members get a liberal education from the student. This association with students keeps the staff members on their toes and encourages them to keep abreast of recent developments.

During the second quarter, the student is encouraged to keep accurate records

of his findings, if his position calls for such records. Each project is brought up to date in the form of a written report at least once a month. When a project is completed, a final report is written and presented by the student. This gives the student the feeling of having contributed to the organization.

Shift Within Production Department

If the student returns to the Company for his third period of co-operative work, it usually means that he is "on the inside." He is probably well liked and quite capable of fitting into the organization. The third quarter is usually spent with the production department. Typical examples of such work are:

Production Department
Typical examples:

1. Time Study
2. Record Clerk
3. Assistant to Department Supervisor
4. Special Production Problems
5. Observer for Quality Control
6. Order Checking before Shipment
7. Inventory Control
8. Stock Room Clerk

The student should be shifted from one job to another during his three months employment in the production department to give him the opportunity of meeting and working with many people. One month is usually the maximum time he spends in any position. He receives training in labor relations, the labor contract, how to give orders, how to discipline employees, personality development, how to work with people, and numerous other humanics necessary to the position he may hold.

If the student passes through the production period with honors and chooses to return to the company for his fourth and last co-operative period, he is usually given training in the sales department. A typical schedule of such training is as follows:

Sales Department
Typical examples:

1. Drafting
2. Equipment Design
3. Product Installation Drafting
4. Product Design
5. Bill of Material Preparation
6. Field Trips
7. Customer Contact
8. Observer of Product Installation

Usually the personality of the student must be fairly well developed by this stage of the training program. He is given every opportunity to work out complete problems by himself, then discuss his work with his superiors. Report writing is emphasized; all customer contact and field trips must be reported in detail. He is instructed in the use of company records and where necessary information can be obtained.

Key Positions Filled by Former Co-op Students

Our experience with this type of program has been very satisfactory. We are most appreciative of the opportunity to have students work with us; we all profit from the experience. Several key positions with the company are now held by men who originally entered our employment through the cooperative plan. It has the distinct value of allowing us to screen people thoroughly. Sometimes we purposely throw stumbling blocks in their paths so that we may observe their technique in solving knotty problems. If they make the grade, they are the men we are looking forward to having as key figures in our organization.

In preparing this talk, I requested the opinions of several co-operative students on what they wanted to get from their co-operative work. You might be interested in their side of the problem. Here is a list of the high points they would like to stress in their training work:

Contacts with industrial relations
Personality in supervision
Leadership in training

Opportunity of gaining respect of their superiors
Discipline
Cooperation
Orientation
Working with people
Facts and figures
Concrete examples of industrial economy
Cost economy
Engineering economy
Practical engineering experience
Typical engineering problems
How to think
Hard work and plenty of it

College Notes

To meet the increasing demand from all types of planning agencies for engineers who have knowledge of planning methods and techniques, the College of Engineering at **Rutgers University** will offer for the first time in September 1952 a curriculum leading to the degree of Bachelor of Science in Planning Engineering. The new program will incorporate courses in city and regional planning with a basic core of engineering subjects. The city and regional planning sequence may be taken not only by engineers, but also by students majoring in Economics, Sociology, and Political Science. Thus, Rutgers will bring together in the planning courses students representing the major fields which are involved in planning operations.

Harold L. Hazen, Head of the Department of Electrical Engineering at the **Massachusetts Institute of Technology** since 1938, will become Dean of the Institute's Graduate School next July, James R. Killian, Jr., President of the Institute announced. Harold Hazen will succeed John W. M. Bunker, who has been Dean of the Graduate School since 1940. John Bunker, who joined the Institute's staff in 1921 as an assistant professor of physiology and biochemistry in the Department of Biology, will retire at the end of the academic year.

Professor Frank A. Record has been appointed chairman of the electrical engineering department at **Clarkson College** and Dr. Theodore S. Renzema has been named chairman of the physics department.

The Board of Education of **Wayne University** announced the acceptance of grants totalling $200,000 from General Motors Corporation and the Ford Motor Company for expansion and maintenance of the large-scale computing machine laboratory at Wayne University.

A grant of $400,000 to the **Massachusetts Institute of Technology** from the Edwin Sibley Webster Foundation to establish an Edwin Sibley Webster Professorship of Electrical Engineering was announced by Dr. Karl T. Compton, Chairman of the Corporation of the Institute.

Determining Teaching Objectives

By FRANK KEREKES

Assistant Dean and Professor of Civil Engineering, Iowa State College

Today a great body of men, including those outside as well as inside of educational circles, has arrived at the important conclusion that there is but one unified fundamental objective for higher education in a democracy. This objective is achieved when through the processes of higher education young men and women develop their intrinsic abilities to perform, in a creditable manner, the work they want to do and to integrate, through service, their lives with those of the other members of their community, State and Nation.

Twofold Objective of Engineering Education

In order that engineering students may attain this fundamental objective their education must be planned to enable them to enter the engineering profession not only proficient in the scientific-technological areas of subject-matter but also well founded in the humanistic-social areas of relationships with society. With objectives clearly developed in these two areas the engineering educator has at his disposal the material upon which he can base essential teaching objectives.

The objectives of the scientific-technological and the humanistic-social areas are the end results in subject-matter which the students should possess in proportion to their capacities to benefit from education.

The teaching objectives are the end results which the students should acquire in the development of their mental power, personal attitudes, and habit formations as a result of the efficiency and effectiveness of the contacts with the members of the faculty.

Each and very course should be so planned and so conducted by the teacher that the students are progressively nearer to the achievements of the scientific-technological and humanistic-social objectives because the qualified teacher is progressively achieving the end results set forth in his teaching objectives.

Objectives of the Humanistic-Social Stem

On the one hand it should be clearly understood from the beginning that the scientific-technological stem applies only to the designation of the type of work and nature of thought and approach to a problem which sets the professional engineer apart in his community. On the other hand, the humanistic-social stem should be common to all men benefitting from the opportunities implied in higher education.

The humanistic-social area of higher education and its subsequent application provides the universal medium in which man must function as a member of society. It is the medium in which each of us contributes our worth to the functioning of the community in which we live, be it the home town, the State or the Nation; it is the medium in which each of us participates and shares in the integrated worth of the entire community.

We, as engineers, must give to as well as take from the benefits of our environment. The development of the humanistic-social consciousness of the individual, be

he business man, or doctor, or lawyer, or public official, or craftsman, or engineer, provides him with the fundamental prerequisites to enjoy the privilege of serving and being served by the members of his community; provides him with an understanding of his own problems and aspirations in terms of the problems and aspirations of others in his community; and, finally, provides him with the power and satisfaction that comes from the realization that he is carrying his full share of the responsibilities of community participation, cooperation and leadership in compensation for the privilege of being an educated man as well as a respected and proficient engineer.

"Humanistic-social thought dealing with the moral, ethical and political aspects of man and his institutions seeks to question situations, to phrase problems, to gather evidence, to weigh values, to make judgments and to direct conduct. It is subjective, qualitative, and seldom free from preconditioned emotional attitudes. Its pursuit in an atmosphere of neutral detachment is practically impossible. Conclusions are usually in terms of good or bad, right or wrong."

The 1940 report of the Committee on Aims and Scope of Engineering Curricula gives the following statement of objectives for the humanistic-social stem:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.

2. Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.

3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.

4. Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.

5. Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.

6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration of continued study.

Objectives of the Scientific-Technological Stem

According to H. S. Rogers: "Scientific-technological thought dealing with nature and her forces makes an effort to observe, to describe, to classify, to analyze, to explain and to use constructively. It is objective, quantitative and logical and is pursued in an atmosphere of neutral detachment. It may be applied in certain humanistic-social studies as for example in the field of economics. Conclusions are usually in the terms of truth or falsehood. This stem deals with objective realities.

"Conclusions are accepted tentatively. We speak of principles and laws as truth with full realization of the fact that they are conditioned by the present state of knowledge. We utilize principles which we know to be inaccurate because they are currently the most useful tools available for the solution of practical problems. Knowledge is considered progressive and the current state approves and accepts, or corrects and amends the earlier."

The Report of Committee on Aims and Scope of Engineering Curricula, Dean H. P. Hammond, chairman, contains the following specific objectives for the scientific-technological stem:

1. Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:

a. Grasp of the meaning of physical and mathematical laws, and knowledge of how they were evolved and of the limitations in their use; and

b. Knowledge of materials, machines, and structures.

2. Through understanding of the engineering method and elementary competence in its application. This requires:

a. Comprehension of the interesting elements in situations which are to be analyzed;

b. Ability to think straight in the application of fundamental principles to new problems;

c. Reasonable skill in making approximations, and in choosing the type of approach in the light for solution—in sum, a foundation for engineering judgment;

d. Resourcefulness and originality in devising means to an end;

e. Understanding of the element of cost in engineering and the ability to deal with this factor just as competently as with technological factors.

3. Ability to select the significant results of an engineering study and to present them clearly and concisely by verbal and graphic means.

4. Stimulation of a continuing interest in further professional development.

Differentiating Characteristics of an Engineering Curriculum

The Institute of Civil Engineers was founded in 1828 in London. On a subject-matter basis this one society sufficed the common technical and professional needs of its members. Even as late as 1852 when the American Society of Civil Engineers was founded one society offered the necessary and sufficient service to engineers of that era. Since then there were founded what we call the principal branches of engineering such as mechanical, mining and metallurgy, electrical, chemical. Since 1900 these principal branches began to sprout twigs, twigs that in many instances have grown into branch size. Civil engineering, for example, also is represented by the American Railway Association, the American Concrete Institute, The American Waterworks Association. The same subdivision on a subject-matter basis is taking place in other engineering societies.

On the one hand this trend in specialization continues as the subject-matter knowledge grows by leaps and bounds in every particular area of application. Furthermore, this trend in engineering specialization will continue to form new groups which will devote themselves to ever narrower fields of subject-matter in terms of basic scientific fundamentals, new technological science, technological empirical data, practical applications, and engineering experience.

On the other hand engineering education must continue to emphasize the attainment of the objectives common to all engineering. Because specialization is the natural and logical trend in engineering practice it becomes all the more important for the engineering educator to determine the basic objects by which to prepare men for broad responsibilities of the engineering profession, for rigorous intellectual requirements, for professional attitudes toward and habits of work, and for attitudes toward people, life and professional standards. In order that the students may achieve these ends the engineering educator needs to formulate specific teaching objectives and techniques.

In an effort to include only those characteristics of the responsibilities of an engineer which clearly differentiate his education, knowledge and training from those of other professional men, Dean S. C. Hollister in behalf of the Committee on Engineering Schools of the Engineering Council for Professional Development formulated, in October, 1949, a statement that will in all probability be acceptable to most engineering educators and to practicing engineers. He proposes that

"An engineer is characterized by his ability creatively to apply scientific principles to design or develop structures,

machines, apparatus or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property."

The engineering educator is challenged to formulate teaching objectives that will apply to the education of all engineering students regardless of the special field of engineering they may choose to follow. These teaching objectives must be related to the functioning of thought, to the strengthening of character, personality and ideals, to the establishment of ethical, moral and political values, and to the development of effective habits of behavior and work. The purpose of these teaching objectives, then, will be achieved in proportion to the individual student's capacity for development and to the individual teacher's skill in the art and science of engineering and education.

First Objective

The engineering curriculum is the prescribed course of study, a framework, within which all the subject-matter objectives are to be achieved. There then follows

TEACHING OBJECTIVE ONE: To design a curriculum which will include only those courses that are fundamental to every branch of engineering, that are basic to the particular curriculum of specialization, and that are generally useful to an educated person.

Objective One will be achieved when each teacher, in collaboration with his associates, arrives at acceptable answers to the following questions in terms of the conditions expressed in Teaching Objective One:

a. What are the basic courses in the humanistic-social stem including English, literature, history, economics, psychology, and human relations essential to the pursuit of engineering work and to the participation in community responsibilities?

b. What are the basic courses in mathematics, chemistry, physics, geology and biology essential to the development and understanding of the fundamental technological sciences—statics, strength of materials, dynamics, fluid mechanics, thermodynamics, electronics, aerodynamics, and soil mechanics?

c. Which of the technological sciences are common to all branches of engineering and which are necessary to the specialized branches of engineering?

d. Which applied technological courses are absolutely essential adequately to prepare a student for entering his chosen branch of engineering?

e. How far shall the engineering colleges go in designing special curricula for offshoots from the established major branches of engineering? That is, shall engineering educators design complete curricula in Construction Engineering, Radio Engineering, Foundry Engineering, Welding Engineering and the like?

Second Objective

The individual courses in each curriculum are the mediums in which the manipulative techniques, knowledge, fundamental theories, and technological practices and standards are learned by the students. Furthermore, and importantly, these individual courses offer the mediums for direct student-teacher contacts. These lead to

TEACHING OBJECTIVE TWO: To *develop* in each course *the abilities* which each student should acquire and improve.

Objective Two will be achieved when each teacher will formulate his answers to the following questions:

a. What *manual* and *operating skills* are absolutely essential in future courses and later engineering practice?

b. What basic *knowledge*—generic principles, simplifying assumptions, empiricisms, derived principles and working

formulas, and specifications and codes of practice—should be included as the minimum requirement for subsequent use by the student in college and in engineering practice?

c. What opportunities does the course offer for the exercise and development of *reasoning power* which will enable the student to arrive at correct conclusions which can be verified?

d. How can the exercise of *judgment* be introduced throughout a course so that the student may make tenable decisions and choices based upon previous experiences in work, theory and application? These judgment decisions are made without formal process of solving the problem. Since judgment is based on past experiences the mind rapidly associates the new situation with similar situations in the past and arrives at a selection, choice, conclusion or solution.

e. What opportunities does the course offer for creative thinking by the student?

Third Objective

In commenting on who is a good teacher, W. H. Lancelot concludes, "Indeed, most of us will agree that the deepest currents of our lives have been turned and strengthened by our really good teachers; and most of us know full well which ones exercised this fateful, yet beneficent, influence over us. How they accomplished these things is probably not clear to us even yet. We can see, however, that the skill which they possessed was of a strange order. It was unlike the skill of the surgeon, or the engineer, or the scientific investigator. It may even appear to have been a higher order of skill than any of these processes; and this may be true, since teachers deal not only with processes of life and nature, as do they, but with things that are even *less tangible and predictable* and that are *harder to control,* such as mental activity and human emotions."

Certainly, those teachers who are considered to be good by generation after generation of students must possess a skill in the art and science of teaching on a scale comparable to the skill of the eminent lawyer, doctor, engineer, minister or business man. The recognition that there is a science to teaching leads to

TEACHING OBJECTIVE THREE: To *master the teaching skills* whereby the objectives of the curriculum as a whole and of each course as a unit may be achieved in a positive manner by the students.

The teacher will achieve this objective when he perfects his skills in motivating his students to take full advantage of the opportunities offered in each course for the development of their manual, mental, moral and social capacities.

To acquire and to improve these teaching skills and thereby to achieve Teaching Objective Three each teacher must devote careful and intelligent effort in answering the following questions.

a. What are the principles of arousing genuine interest and how can these principles be applied in each course?

b. How can the students be stimulated to strive toward high ideals and mature purposes?

c. What techniques are available to the teacher so that his students will gain a true relationship between new facts, theories and principles and those already experienced? How can the ability to understand be stimulated and strengthened?

d. What are the techniques by which the abilities, namely, manual skill, basic knowledge, reasoning, judgment and creative thinking, may be put into action spontaneously as they are needed by the students?

e. What means are available to the teacher to bring about those emotional responses and attributes which give the students the urge toward high and worthy professional and community achievement?

Fourth Objective

Perhaps the most characteristic function performed by the engineer is that

of solving problems. In the solution of his problems the engineer employs a definite sequence of thought and a special body of knowledge based upon facts and principles which have been classified as follows in the 1944 Report of Committee on Engineering Education After the War:

1. *Generic Principles* of the fundamental sciences.
2. *Basic Assumptions* which are made for the purpose of simplifying the conditions of the problem and the related mathematical solution of the physical phenomena.
3. *Empiricisms* such as physical constants and properties of materials which have been observed and measured in the field or in the laboratory.
4. *Derived Principles* forming the theoretical and fundamental background for the applied engineering practice.
5. *Specifications, standards and codes* which represent the engineering profession's accumulated experience in analysis, design, production and construction.

Since the ability to solve problems involves a tremendous amount of operating skill, theoretical and empirical knowledge, reasoning power, judgment decisions, and creative thinking, it seems reasonable to set up

Teaching Objective Four: To *prepare problems* whereby the student may test his powers of applying engineering thought and practice in terms of the fundamental abilities that typify the thinking processes.

To achieve this objective the teacher should be prepared to answer the following questions relating to the design of thought-provoking rather than memory-testing problems. It has been said that "Where there is no thinking there is no learning; where there is no learning there is no teaching."

a. What are the distinguishing characteristics of good problems?

b. How can problems be designed so that the objective is the solution and not the mere repetition of memorized facts and procedures?

c. Should problems preferably reflect actual life situations?

d. To what extent should simplifying assumptions be introduced?

e. Is it desirable to select concrete problems to which knowledge, previously acquired, may be applied? (Deductive)

f. How can problems be designed to assist in the understanding of knowledge? (Why, causes, reasons, explanations)

g. How can problems be used to establish new facts or generalized truths? (Inductive)

Fifth Objective

In addition to the mastery of knowledge and development of the power of constructive thinking there should be a continual growth in the personality of the student. This goal leads to

Teaching Objective Five: To bring forth and strengthen the personality traits of each student in terms of personal effectiveness whereby each student may succeed intellectually and in terms of social effectiveness whereby each student becomes appreciated and respected by his associates.

To achieve this objective the teacher should study what techniques are available after he has determined the major personality elements of traits that make up personal and social effectiveness. These techniques should be applied throughout each course and paralleling all contacts with the students. He should develop answers to the following questions:

a. How can the following traits of personal effectiveness be developed in students while they are pursuing their regular course work?

1. Confidence
2. Initiative
3. Thoroughness
4. Industry
5. Enthusiasm
6. Integrity
7. Dependability
8. Accuracy

b. How can the following traits of social effectiveness be developed in stu-

dents while they are pursuing their regular course work?

1. Appearance
2. Physical vigor
3. Social qualities
4. Tact
5. Tolerance
6. Cheerfulness
7. Spirit of service
8. Emotional control

Sixth Objective

The engineering method of thought is generally explained as the differentiating characteristic of the approach and solution of a problem by an engineer in contrast to the approach and solution employed by others. Professor D. W. Mead has said: "The purpose of technical education is not so much to impart technical knowledge to the student as to furnish training which will enable him to think clearly and accurately,

a. To understand and investigate the conditions which surround a problem,

b. To determine the fundamental principles upon which its successful solution depends,

c. To ascertain and analyze the elements which influence or modify it,

d. To design the structures, machines, engines and works needed for its successful development,

e. To supervise the proper construction of such works and production of such machines, engines and equipment, and

f. To carry them to the consummation of a successful and economical completion."

These observations lead to

TEACHING OBJECTIVE SIX: To develop the ability to think well in both the scientific-technological and humanistic-social areas.

To achieve this objective the teacher should assimilate the basic principles of the laws of learning and he should apply these in all his contacts with students in the lecture room, design class, and laboratory. In preparing himself the teacher should seek answers to the following questions:

a. What types of problems and questions will stimulate alert association of the requirements of the new problem with previously acquired knowledge and concepts during each class period?

b. How can each assignment become either a problem-solving process or a process of organizing and interpreting qualitative and factual data?

c. How can the habits of the students be oriented and established by reaching an early inference as to the probable answer of the problem, by search for further available pertinent information, by arriving at a conclusion in agreement with the available data, and by testing the soundness and validity of the conclusions?

d. How can student discussion be motivated, sustained and directed?

e. Can students be trained to test their own conclusions?

f. How can clear thinking, accurate reasoning and sound judgment be introduced into student work and discussion?

g. How can the creative urge be awakened, directed and developed?

Seventh Objective

To do one's best there must exist an inward desire for improvement, achievement and service. Ideals are the prime motivators that cause men to contribute their skills and possessions for self-improvement and for the improvement of their social and physical environment. Therefore, there is needed

TEACHING OBJECTIVE SEVEN: To lead students to adopt high ideals toward their work, their thinking and toward their relationships with other men and groups.

The teacher may acquire the guiding principles to the stimulation of his students' desire to strive for ideals by arriving at conclusions or answers to the following questions:

a. What ideals does the teacher possess?

b. What are the motivating elements that cause students to respond to ideals?

c. Do interest in the subject and respect for the teacher contribute to the acceptance of ideals by the students?

d. Is there a limit to the nature of ideals which students comprehend? Are the ideals acceptable by Freshmen less challenging than those by Seniors?

e. Is there any relationship between the value of an ideal and the expenditure of thought, time, energy and expense to achieve it?

f. Can ideals be imposed or preached or must they be accepted by the free will of students on the basis of appropriateness and merit?

g. To what extent do feeling and emotion enter into the motivation of ideals?

h. Can the proper emotional situation be created for arousing ideals?

i. How can a student be led to the conviction that there is merit in an ideal so that he will spontaneously work toward the achievement of an ideal?

j. Are people likely to let others know about the ideals they have set for themselves?

k. How can ideals be kept alive and growing?

l. What approaches are available to interest students so that they will choose high ideals voluntarily and that they will pursue them intensely and continuously through their lives?

Conclusions

It is entirely possible to achieve the general purpose of education in engineering by emphasizing performance in work, power in thinking, and ideals in attitudes and in behavior.

The curriculum offers the framework for acquiring the mastery of knowledge in the scientific-technological and the humanistic-social areas of thought and action.

The method of teaching offers the framework for acquiring the power of constructive thought by students.

The power to think breathes life into the body of knowledge. The power to think is the chain-reaction of the mind whereby infinite applications can be made from a finite amount of knowledge. The power to think creates and extends the boundaries of knowledge. The power to think is life; the mastery of knowledge is substance. The two are inseparable. They exist together; they perish alone.

Thus the time is at hand when educators must rise to the challenge that there is a science and art applicable to teaching. Unless this science and art of teaching is applied to the development of the power in thought of students, the mastery of knowledge will be still-born and of little use.

Teaching Objectives

1. To *design a curriculum* which will include only those courses that are fundamental to every branch of engineering, that are basic to the particular curriculum of specialization, and that are generally useful to an educated man.

2. To *develop the abilities* (to do and and to think) which each student should acquire and improve in each course.

3. To *master the teaching skills* whereby the objectives of the curriculum as a whole and of each course as a unit may be achieved in a positive manner by the students.

4. To *prepare problems* whereby the students may test their powers of engineering thought and practice in terms of fundamental abilities that typify the thinking processes.

5. To *bring forth and strengthen the personality traits* of each student in terms of the personal effectiveness whereby each student may succeed intellectually and in terms of social effectiveness whereby each student becomes appreciated and respected by his associates.

6. To *develop the ability to think well* both in the scientific-technological and humanistic-social areas.

7. To *lead students to adopt high ideals* toward their work, their thinking and toward their relationships with other men and groups.

General Education in the Land-Grant Institutions

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Right at the start of our consideration of the subject before us on this occasion, a question of orientation needs to be raised: To what extent should general education in the land-grant institutions be different from general education in other types of institution?

In giving answer to this question, reference is bound to be made to the statement of purpose in the founding Morrill Act of 1862. This Act set up its large granted public lands for the endowment, support, and maintenance of at least one college in each state or territory where the leading should be "to teach such branches of learning as are related to agriculture and the mechanic arts." But other parts of that original statement of purpose are today of equal importance. Thus the Morrill Act stated explicitly that "other scientific and classical studies" were not to be excluded. Even more significantly, it concluded its declaration of purpose with these words: "in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

The "industrial classes" of 1862 were the farmers and laborers—the common folk of the time. What the Morrill Act undertook to provide for these people was higher education that was *both* liberal and practical. It was to be education fitting the common man for the "several pursuits and professions of life."

I question whether any broader charter for general education could have been drawn. True, as a matter of historical development, the land-grant institutions have stressed the practical, scientific and professional. But the charge under which they were established gave them educational responsibilities of a comprehensive character. This has been strikingly reflected in the more recent development of the land-grant colleges and universities. As matters now stand, it would seem perfectly clear that the land-grant institutions have the same obligations with respect to general education that other comprehensive institutions of higher learning have—perhaps no more but surely no less. It is on the basis of this conception of their function that I shall make my observations on what may be expected of general education in the land-grant institutions in this second half of the 20th century.

Interest in general education was never more widespread than it is today. This is true both inside and outside the teaching profession. Lay discussion of educational problems is reaching an all-time high. Part of this lay interest probably stems from a concern of parents over what appears to be happening to their own children. But a wider source of interest lies in an almost universal anxiety over the state of the world. Values we have long cherished seem to be in jeopardy. Established customs are being uprooted. Advancing technology is outstripping our means of social control. Divisive forces threaten our basic social solidarity. We have become more and more confused, uncertain and distrustful. We look about

for help. What more natural than to assert: Education should be contributing more than it is!

Capacities of Formal Education not Unlimited

It should be. But just what, and how? The capacities of formal education are not unlimited. Home and church share the responsibilities which school and college have to carry. Moreover, powerful influences, such as those exerted by movies, magazines, newspapers, radio, and now television, may adversely affect what formal education is trying to do. We are most likely to make formal education more effective if we recognize from the outset the bounds within which it has to operate.

Even with these limitations recognized, the role of formal education is tremendously important. The schools have possession of the nation's children and youth for a substantial part of their waking hours during most of the formative years of their lives. What the schools can do with this opportunity is immeasurably great. This is especially true in a period of turmoil and conflict. The responsibilities of formal education in America were never greater than they are right now.

These responsibilities can be spelled out in terms of the purposes of total education in a free society. If terms are kept general the present task of education can be described in a number of different ways. We may speak of the task as one of transmitting the cultural heritage. We may refer, on the other hand, to the job of promoting the greatest attainable individual growth and development. Or we may cite the necessity of inducing an adequate individual and collective discipline of body, mind, and spirit. We may spell out the human traits, relationships, and organizations requisite to the preservation of freedom. We may specify the social arrangements and controls demanded by advancing science and technology. These and other identifications of the task of education in a modern free society advance ideas which are certainly germane to the shaping of formal education for the kind of world in which we now live. However, they all have the same deficiency. They leave wide open the problem of formulating concrete educational programs.

Obstacles

The translation of general educational purposes into specific school and college programs encounters all sorts of obstacles. Three sources of chronic difficulty may be cited: (1) disagreement as to the nature of the learning process; (2) competition of specific educational interests; and (3) excessive generality of statement in the formulation of objectives.

The extent to which learning should be sought through the exercise of arbitrary authority by the teacher has been a subject of dispute among both educators and laymen for generations past. The debate has become somewhat acrimonious in recent years. The progressives have urged the importance of making materials and methods "meaningful" to the learner. The conservatives have stressed the necessity of class-room discipline. On balance in the dispute, the importance of learner interest has been increasingly recognized. In due course, as views become less extreme and educational research makes further progress, this area of disagreement promises to assume less formidable proportions.

A competition of interests lurks in every educational program. Demands have to be compromised and brought into some sort of balance. The essentialists clamor for more attention to the "3 R's" while others urge the necessity of widening the range of the learners' interests and appreciations. The vocationalists play upon the natural concern of youth with that first job and jam the program of instruction with technical offerings. The corrective for all this is a comprehensive view of the relative importance of values to be sought through total education. Such a comprehensive view is an essential of

educational statesmanship. The broad view cannot easily be had but if achieved will resolve many of the most serious conflicts with which formal education in recent years has been afflicted.

Excessive generality of terms is a persistent ailment of statements of educational goals. Thus it is all very well to state that it is the job of education to produce the "good citizen," or the "extraordinary American," or to prepare young people for "wholesome home and family living," or to induct those who enjoy freedom into the "good life." The trouble with such statements, clearly enough, is that they can "mean all things to all men." Hence they do not start anything. Statements of educational purpose should stir people. If they do not prove controversial the chances are they are too general. In other words they are not sufficiently specific. A higher order of specificity is the crying need of current discussions of the purposes of education.

Educational Objectives

There are those educators who will contend, ordinarily with some show of impatience, that it is a waste of time to talk any more about educational objectives. The idea is that all that can be said on the subject has been said, or that consideration of this particular aspect of education has passed the point of profitable return. I am myself convinced that this is not at all the case. We are still very much in need of a more incisive discussion of just what we are trying to do educationally.

It is as if we were navigating at sea. It made sense for Columbus to set sail with no more definite idea than to sail west. But what shipper, unless on pleasure bent, would sail out into the ocean today without a definite country or port of destination? Furthermore what captain of a ship would sail without knowing the means by which to guide his course? It is high time that education charted its course more specifically.

There are at least three different approaches to the analysis of educational objectives. We may think in the first place in terms of the physical, intellectual, emotional and motivational growth, and maturation of the individual. Or we may recognize the various roles or functions of the individual in society; as consumer, producer, home-builder, parent, neighbor, citizen—of the local community, the state, the nation, the world—and as an integrated person seeking the "good life." Or instead of these approaches we may come at the analysis of objectives in terms of specific outcomes: interests, skills, knowledge, understanding, attitudes and ideals, habits. It is my considered opinion that this third approach is the one most likely to prove fruitful, keeping in mind all the time the various roles the individual will be called upon to play.

Let us agree then, at least for the present discussion, that it is the job of total education to: (1) arouse interests; (2) develop skills; (3) convey knowledge; (4) impart understanding and appreciation; (5) establish attitudes and ideals; and (6) cultivate habits. We are then faced with very concrete questions. What specific interests, skills, knowledge, understanding and appreciation, attitudes and ideals, and habits are to be sought? Which of these are to be regarded as of most importance, which of lesser importance? What means, curricular and extracurricular are to be employed in the effort to secure the desired outcomes? These are some of the questions that have to be faced squarely and constructively if education is to render a greater total service in the present troubled world.

Lines Along Which Thinking Needs to Proceed

To pursue this line of thinking all the way through to definite conclusions would take a lot more time than is available on this occasion. All I can hope to do here is to suggest by way of illustration the lines along which thinking needs to proceed.

Take the subject of interests. One of

the earmarks of advancing civilization is a greatly expanded range of sustained interests. Primitive man was satisfied with little, modern man wants much. Many of his articulate wants relate to devices and implements of every sort. With reference to arousing interest in these material possessions, formal education needs to do little if anything. The advertisers take care of that. But what of interests in people, with special reference to the strikingly diverse conditions under which they live and strive? What of interests in art and the things that make for beauty in life? What of interests in the joys and satisfactions of the intellectual life? What of interests in the struggles and aspirations of the human spirit? The drives of materialism, opportunitism and provincialism are formidable in the world of today. Formal education is charged with the duty of doing all it possibly can to arouse interests that will combat these threatening forces of the current social order.

What of necessary skills? The three R's have, of course, long been recognized. In recent years, the importance of speaking and listening is being more and more stressed. In general the arts of communication are certain to be included in any listing of the skills to be cultivated through formal education. The problem here is not one of setting objectives but of raising the level of their attainment. The same is true of certain closely related goals having to do with the ability to think logically, objectively, reflectively, imaginatively, and constructively. There is a better training of the mind at all levels of native intelligence which is desperately needed these days. But these are matters with respect to which educators will not seriously disagree, at least so far as the purposes and ideals of education are concerned.

But what of certain other skills? Take, for example, those skills which relate to bodily controls and physical coordination. These certainly have their bearing upon the maintenance of physical health. And how about those skills which facilitate wholesome recreation; such as a well-grooved golf swing acquired at age 12! Should skills of this sort be of any concern to education.

Then there are those skills which have to do with sound human relations in a free society. How to get along amicably and effectively with others is a definite art. It varies with the degree of intimacy involved. Some individuals grow up exceptionally endowed for success in the practice of this art; others have to learn the hard way. But learn they can, at least in some measure, if they are wisely instructed. Skill in cooperation is an extremely important skill in a democracy such as ours. To what extent and by what means should formal education undertake to develop it?

Other Skills

Other skills that have to be considered fall into the field of the creative arts. There are latent possibilities along this line that have still to be fully explored. Then there are skills that many people need to acquire to achieve emotional stability. The requirements of mental hygiene become increasingly clear. Some involve skill in developing certain practices and avoiding others. Perhaps these are skills that lie beyond the reach of formal education, but the area is one that invites careful analysis.

Skills that have to do with specific vocations or professions fall outside the scope of general education, but are clearly enough recognized in total education. By and large, education succeeds remarkably well in developing these particular varieties of skill. In so far as deficiencies develop in this type of educational undertaking, they are likely to take the form of an unduly restricted conception of the skills the learner is likely to need later on in his working career, say, at age 45.

Let us turn next to knowledge as an educational objective. Here the basic question is: knowledge to what end? It may be contended that knowledge is an end in itself. Is it not true that "knowledge is power"? But education is packed

with evidence that knowledge of the sort conveyed in class-room instruction is highly ephemeral, and quite commonly divorced from any subsequent behavior of the learner. The chances are that educational planning will be markedly improved if knowledge is regarded as a means to an end—the end being found in other desired outcomes of the total educational undertaking.

Even so the inculcation of knowlege as such remains a major educational objective. We therefore face the problem of deciding what knowledge to convey. Without attempting to give the whys and wherefores, I would myself identify the following subject matters for inclusion in the total program of general education:

1. The physical universe.
2. Human growth and development.
3. The Great Society.
4. The cultural heritage with special reference to the Judeo-Christian tradition.
5. The meaning and implications of Democracy on a world-wide scale.
6. Human relations with emphasis on moral and spiritual values.
7. The nature of knowledge and of its acquisition.

Whether or not knowledge in fields such as these has been actually imparted can be ascertained, of course, by appropriate testing. What is more, its retentioin can be encouraged by later examinations of a general or comprehensive character. This is one of the areas in which formal education can proceed with greatest assurance of success in attaining its declared objectives.

When objectives take the form of understanding and appreciation, and even more when they deal with attitudes and ideals, complicated value judgments have to be made and educational achievement becomes much more uncertain. Yet objectives of this more difficult sort must be recognized and set if education is to meet its responsibilities in a divided world.

Time on this occasion does not permit any analysis of the specific aims which formal education should acknowledge in these areas in which esthetic, ethical, moral and spiritual values play a decisive part. However the supreme importance of concrete and unequivocal aims in these areas cannot be seriously questioned. For example, with respect to such matters as the inculcation of proper standards of honesty and personal integrity, formal education must take a positive stand. Just what measures can best be adopted to attain objectives of this character may be open to question, but refusal to accept responsibility for "character building" will not do. Nothing is more needed in educational planning these days than clarification of objectives in these areas relating to understanding and appreciation, attitudes and ideals, and habits tending to perpetuate good practices.

Points to Keep in Mind

May I conclude with the citation of four or five points which need to be kept constantly in mind in attempting to increase the effectiveness of general education.

The temporary acquisition of knowledge as such tends to get over-emphasized in formal education. The presentation of factual materials is the simplest type of teaching assignment, and the possession of knowledge at the point of examination is the easiest type of learning to measure. If instruction follows the lines of least resistance it will end in an over-done effort to convey knowledge. Other outcomes of equal and perhaps greater importance will thus fail to get the attention they merit.

Attempts to identify these other outcomes in concrete detail ordinarily result in a multiplicity of specific objectives. While all of these may be deserving, their very number serves to introduce a measure of diffusion if not of confusion, in the direction of educational activities. What is needed is a system of priorities. Certain objectives must be recognized as primary in importance, others as secondary or teritiary. It is hardly necessary to add that these ideas of relative importance may reasonably reflect the particular

needs of a given phase of political, economic, or social organization and development.

The potential impact of the *total educational enterprise* has to be considered in seeking the attainment of some of the objectives of general education. Extracurricular as well as curricular activities have to be brought to bear. Thus the operation of a student union or the promotion of an effective organization for student self-government may contribute significantly to the attainment of important skills and the establishment of indispensable attitudes and ideals. It is only through a consistent total educational experience that we can hope to reach certain of the goals of general education.

This points to the necessity of integration. Efforts to sharpen the objectives of general education, or in the wording we have previously used, to make them more specific—must not be allowed to result in any fragmentation of the educational program. Certain units of instruction may be required in order to pull things together. More essential, however, is an explicit educational philosophy governing the entire operation in all its parts.

Continuous Evaluation Necessary

Finally it is important to recognize the place of continuous evaluation. One of the strongest reasons for setting objectives more specifically is that only so are we in a position to measure the effectiveness of our procedures. We greatly need in education to know more definitely whether or not we are succeeding. We need to experiment with a better chance of knowing what results we are obtaining. Comprehensive and critical appraisal should characterize the whole process of seeking to achieve more fully the purposes of general education.

Total education, as the biggest single force in the development and conservation of human resources, has surpassing importance. For a world in conflict it becomes absolutely essential that this great force be given as sharp and sure a direction as educational statesmanship can achieve. Hence reexamination, reappraisal and redirection of the educational enterprise are all from time to time in order. They surely are in order right now. Basic planning activities of this sort have had too little attention. It is high time that the institutions in this Association made such planning a matter of major concern. If they do they may initiate a land-grant movement of the 20th century as significant as that which revolutionized American higher education in the second half of the 19th.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College Hanover, N.H.

The Technical Institute Comes of Age

By EDWARD E. BOOHER

Vice President, McGraw-Hill Book Company, Inc.

Introduction

Surely and not too slowly the technical institute seems to be coming of age here in the United States. Its development and its recognition as an important part of the over-all technical education program of the country have been fairly rapid during the past decade. Today, I hope I can give you some idea of the present status of technical institute education here in America and its evolution as we have watched it for the past 10 years through the publication of *Technical Education News*. As many of you know, *TEN* provides a fair vantage point, for it serves as a medium for exchange of information, ideas, and opinions in this field—a sort of quasi-official sounding board.

Although technical institutes have been turning out graduates continuously for over 100 years, I feel that it is reasonable to state that the so-called modern era of technical-institute education, or at least recognition of this type of education, began just 20 years ago with the publication of the Spahr-Wickenden report. This classic study brought together for the engineering profession for the first time all the pertinent information needed to appraise the status of, and need for, the type of work then being offered by institutions such as Wentworth Institute, Franklin Technical Institute, Rochester Institute of Technology, The Ohio Mechanics Institute and a few others. Also, this report produced almost indisputable evidence that industry needed approximately 3 trained technicians or semi-professionals for every employed engineer. Yet, at the time of Mr. Spahr's survey approximately 9000 engineers were being graduated annually (by approximately 150 colleges and universities), whereas interpolation of the data in his report shows that roughly 1800 technicians were being graduated from day and evening courses in technical institutes. In other words, the actual ratio of graduates at that time, 5 engineers to 1 technician, was far removed from the desired ratio of 1 to 3. Now, some 20 years later, we find that this ratio, though greatly improved from the standpoint of Mr. Spahr's recommendations, is still in inverse proportion of 3 engineering graduates to 1 technician graduate. (Approximately 50,000 engineers in 1950 to 15,000 technical institute graduates.)

At the time of its release, the Spahr-Wickenden report created considerable discussion among engineering educators, but little happened, for these were the depression days of the 30's. For the next 15 years the technical institute type of education continued to be confined to a few well-established, endowed institutes and to the few proprietary schools that were practical enough to recognize the need for trained technicians. Supplementing these schools during the 30's was a growing number of junior colleges that offered technical-terminal programs as well as lower division general college courses.

Although there was some stirring in the technical institute field as early as 1940, it was not until we were well into World War II that the crucial need for trained technicians was thrown into sharp relief.

And as we all know, the real genesis of the renaissance in technical institute education was largely in the ESMWT courses that blanketed our educational institutions throughout the war period. The phenomenal growth of these courses and their successful operation did much to highlight the great need for a continuing source of trained technicians.

Developments

I'd like to recount some of the events and developments that point up the fact that this need is being recognized and partially met, that the status of the technical institute today is dynamic in comparison with its somewhat somnolent past.

ECPD

First on my list of events that mark the "coming of age" of the technical institute is accreditation of technical institute curricula by the Engineers Council for Professional Development.

Although the Spahr-Wickenden report had recommended the establishment of an accrediting agency, no action was taken by anyone until a group of technical institutes petitioned the ECPD for help in 1940. From that date forward, there was continuous progress.

ECPD appointed a Sub-Committee on Technical Institutes in 1944. On February 1, 1945, under Dean H. P. Hammond's chairmanship, this sub-committee announced that it was ready to accept applications from technical institutes for accreditation of their curricula under a set of standards and procedures with which all of you are familiar. Like most jobs undertaken by the ECPD, this was a difficult one, and as most technical institute administrators know, the performance of the committee was thorough. To date some 51 curricula of 20 schools have been accredited.

Dean Hammond received the first James H. McGraw Award in Technical Institute Education for his successful leadership as the first chairman of this ECPD subcommittee. As all of us who watched this development know, this award was small recognition for his untiring interest and for the stature he was able to lend this development. I'm sure that most technical institute people feel that the technical institute field will always be in his debt.

ASEE

The second important development in the technical institute field and one evolving concurrently with ECPD accreditation was the recognition by the Society for Promotion of Engineering Education of the technical institute as an integral part of engineering education.

This milestone was passed in 1941 when the SPEE created a Technical Institute Division. I might add parenthetically that McGraw-Hill's inspiration to start TEN came from the first meeting of this new division held in June, 1941, at Ann Arbor. Volume I, Number I, of *TEN*, published in September, 1941, carried a report on that meeting by the late John T. Faig, its chairman.

Although the division survived the next 5 years, it had a lean time, as, also, did most technical institutes. During some of those years there was no formal technical institute program at the annual SPEE meeting. The Technical Institute sessions, such as they were, often were held informally around the dinner tables or in the rooms of hotels that served as SPEE headquarters, with the late Walter Hughes of Franklin Tech., Ken Holderman of Penn State, and a few other zealots always planning for the future.

Well, the future arrived in 1947, when at the 55th annual SPEE meeting in Minneapolis there was a planned, announced technical institute program attended by all of 38 interested educators.

From then forward, the Technical Institute Division of the American Society of Engineering Education has had a very steady growth. Its program at the annual meeting in East Lansing last June reached a new high in meaning and interest and certainly in attendance, with 126 people attending one or more of the technical institute sessions.

NCTS

Next on my list of relatively recent developments in the technical institute field —and one we tend to overlook because we don't hear much about it—is the growth of the National Council of Technical Schools.

Some of you may remember that the National Home Study Council, which as an accrediting agency and trade association for the better correspondence schools, grew out of a study of such schools made in 1926 by the Carnegie Foundation. Certain trade and educational practices in this field at that time had been questioned by many people. The Carnegie Study and the subsequent creation of the National Home Study Council did much to purge those questionable practices. Now virtually all respectable correspondence schools operated for profit are members of that Council. Many of these correspondence schools, such as the Capitol Radio Engineering Institute and the Chicago Technical College, also offer resident courses at the technical institute level. It was this group of schools with membership in the NHSC that furnished the leadership for the formation in 1943 of a similar agency for all private, resident technical institutes—the National Council of Technical Schools. This Council is a trade association of some 20 private schools, most of which are proprietary, although two or three endowed schools hold associate memberships. Concerned with educational and business standards and practices, the Council, through its widely distributed literature, promotes its member schools, as well as the technical institute type of education in general, to secondary school students. It in no way conflicts with the ECPD. In fact, the Council has urged its membership to apply for ECPD accreditation, and to date 11 member schools have one or more accredited curricula.

Directory of Higher Education

Another mark of recognition for technical institutes and fourth on my list is the listing of about 40 such schools in the higher education section of the Education Directory of the United States Office of Education for 1949–50. This list would be considerably more extensive if some of the universities included therein listed separately the technical institute programs conducted by them.

Literature

Point number 5 that I should like to make revolves about the evidence of a growing maturity in technical institute education as reflected by the developing literature of this field.

At the moment, there is in process a compilation of a bibliography of technical institute literature by an ASEE committee on technical institute studies. A preliminary report of this committee reveals some 300 entries consisting of articles, graduate theses, and books. The great majority of entries have been produced during the past 10 years.

Also, there is an important, growing literature in the form of surveys made by the federal government, by state agencies, and by various committees of the Technical Institute Division of the ASEE. Most of you are familiar, I am sure, with two important studies made by committees appointed by the U. S. Office of Education. The first, released as *Vocational-Technical Training for Industrial Occupations,* appeared in 1944, and the second, entitled *Vocational Education of College Grade,* came out shortly thereafter.

New York State conducted what is probably one of the best surveys ever made in the technical institute field. This study was preliminary to the establishment of five new institutes of applied arts and sciences and to the creation of a unified state program of technical institute education embracing these new institutes as well as the old technical and agricultural institutes. This survey, conducted by Dr. Kenneth Beach, included a rather intensive and comprehensive study of the need for technicians in the industries of New York State. Not only did the

survey enable the state to localize intelligently the need for technicians on a geographic and population basis, but it revealed the surprising need in these areas for 7 technicians to each engineer. Entitled *Technical Occupations in the State of New York with Implications for State Institutes of Industrial Arts and Science,* the survey was never distributed generally, although I'm sure copies are available on a loan basis from the New York State Department of Education.

Those who have attended the Technical Institute sessions of the two most recent annual ASEE meetings are also aware of the important studies being carried on by certain standing committees of the Technical Institute Division. The committees on Student Selection and Guidance, on Curriculum Development, and on Teacher-Training are doing research in areas that should result in the addition of important, useful literature.

While on the topic of literature, I should mention the growing number of doctoral studies in or touching upon this field that have come to our attention during the past five years. Also, last but not least—to my way of thinking, of course—I should mention the growing textbook literature. While still inadequate, it is ample evidence that teaching materials for the technical institute are being steadily developed. At least three publishers have established publishing departments catering to this field during the past 10 years.

Completion Credentials

Turning now to another development, number 6 on this seemingly endless list, I should like to bring you up to date on the matter of completion credentials.

One of the conclusions reached in the Spahr-Wickenden report was that technical institutes had been handicapped by the fact that their graduates received no educational credentials which were generally recognized. Yet, for a number of reasons, no recommendation was made other than to state—"The matter must remain inconclusive until the representatives of the technical institutes are themselves prepared to take the initiative." It seems that the technical institutes are now about prepared to take such initiative.

For the past two years, the Technical Institute Division of the ASEE has had a working committee on completion credentials. In East Lansing last June, the chairman of that committee, R. Warren Marsh of Buffalo Institute of Applied Arts and Sciences, reported preliminary findings of his committee as follows:

1. Over 300 firms employing in excess of 7000 technical institute graduates reported by questionnaire the titles or terms used to designate a technical institute graduate.
2. A total of 149 or slightly less than one-half of the entire returns indicated the title of technician or some modification as being used at the present time.
3. 77 or about 25% of the total indicated some form of engineering or associate.
4. Others indicated a wide range of titles, many of which were simply job titles such as draftsman, estimator, etc.

Mr. Marsh's committee is continuing its work this year and possibly at the next annual meeting will be ready to make some final recommendation.

In the meantime, however, a few institutes, notably those of New York State, have adopted the accepted junior college degrees of Associate in Arts or Associate in Science.

Growth

Finally on my list of items which bespeak the position of technical institute education today is the actual growth in the number of institutes, and even more important, the growth in technical institute enrollments.

Perhaps our most reliable data on this growth is that found in the annual survey of technical institutes prepared by Leo Smith, Chairman of the Educational Research Office of Rochester Institute of

Technology. These surveys, incidentally, have appeared in the June issues of *TEN* for the past seven years. Let's look at his figures: For the school year 1945–46 * the survey showed a total of 69 institutes. In 1950–51 Smith lists 66 institutes. His data tend to be misleading in that they indicate a decline in the number of institutes. Actually this is not so, since two universities that have established several technical institutes during the past six years are listed as single institutions. Making the proper adjustments, we find that the total number of technical institutes has grown from 69 in 1945–46 to 80 in 1950–51. Referring to this same period, we find an even more impressive growth in enrollments. Total enrollments, day and evening, were 18,656 for the year 1945–46, while by 1950–51 Smith shows they had climbed to 46,441. This increase of 150% in technical institute enrollments for a 6-year period compares most favorably with an increase of 135% in engineering enrollments which for the same period went from 69,146 to 161,592. And, of course, these figures represent a healthy rate of growth since 1928, when the Spahr-Wickenden figures of 4115 enrolled in 10 technical institutes represented approximately one-half the total enrollment at that time.

In addition, there are recent developments too new to be included in Smith's figures that also reflect a continued growth. For example: (1) New Hampshire has recently converted two former trade schools to state technical institutes with programs on the post-high-school level. (2) The Marine Corps Institute has recently revamped part of its program to offer courses that meet technical institute standards as defined by the ECPD. (3) The Louisiana State Department of Vocational Education has recently completed a survey recommending the establishment of several two-year technical institute curricula and requiring 3 new institutes on the post-high-school level. Incidentally, this survey, like that done for New York State, is an interesting piece of work, for it attempts to establish 3 rather basic sets of data—first, technical occupations for which curricula should be provided, second, the number of students for whom provision should be made, and third, the geographic areas of the state in which these curricula should be offered. Another interesting point covered in this survey is the ratio of technicians to professional engineers, which varied from 3.6 to 1 in crude petroleum production to 31.6 to 1 in contract construction. Copies of this 51-page report are available from the State Department of Commerce and Industry, Baton Rouge, Louisiana.

All of this speaks well for the technical institute as we examine it today in light of its growth and recognition over the past 20 years. I know that Mr. Spahr, when he received the technical institute award in East Lansing last June, felt that the strides made in this field during the past 10 years have far outstripped his most optimistic estimates.

The Future

But with this perspective of the past 20 years to guide us, wouldn't it be well to appraise the future of the technical institute in the next 20—to prognosticate a bit?

Frankly, I'm not sure that the outlook for the future is as good as the trends of the immediate past would indicate. In making this statement, I have in mind the technical institute as we have known it, a distinctly individualistic institution rendering an industrial service as an important part of the whole of engineering education. My reasons for so feeling are two, and neither centers around anything so tangible or concrete as UMT, for example. Problems of this type usually can be met and assimilated. Nor can my reasons be founded on the prospects of a diminishing need for technicians or diminishing enrollments. Enrollments in

* The data of Smith's first survey covering the school year 1944–45 is somewhat incomplete. Therefore, for the purposes of this paper we are omitting that first year and using only the data from the last six years, 1945–46 through 1950–51.

higher education are forecast to reach 3,000,000 by 1960 compared with 2,225,000 today, although they may continue to decline slightly up to 1956, when the population curve representing individuals of college age reverses the downward trend found today. Actually the prospects for technical institute enrollments in the next 10 years are very healthy. Probably the need for industrial technicians will be greater than ever before.

My first reservation about the future growth of the technical institute is conditioned by the seemingly certain growth of the junior college, or community college, as it might more accurately be termed.

The community college is a potent, dynamic force in American education. Its strong, aggressive leadership is casting covetous eyes on the field of technical-terminal education, so much so, I feel, that this type of institution may in the future assume the function of the technical institute as we have known it. Here are some figures to make us sit up and take notice. You will recall that Smith's surveys show a total increase of 11 new technical institutes in the past 6 years. But the Directory of Higher Education for 1950 states that 89 new institutions of higher learning were established in the United States in 1949 alone, and that more than one-half of these are junior, or community, colleges! Further, Earl J. McGrath, U. S. Commissioner of Education, predicted last year that by 1960 an additional 500 community colleges will have opened their doors. It is my guess that a majority of these new community colleges will include in their offerings courses of the technical institute type, and in many instances full technical institute programs.

Why does the junior, or community, college seem to be such a threat to the technical institute we have known? What evidence of its movement toward the field is there?

First, as a strong social force, its 1950–51 enrollments stood at 562,786 in 634 institutions according to the 1951 Junior College Directory. In other words, there are 8 times as many junior colleges as technical institutes, with enrollments over 10 times as great.

Second, the junior, or community, college through its American Association of Junior Colleges presents a united front, strong in local, state, and national political influence, strong in promotion of its basic educational concepts, and strong in developing new ideas and ideals for this area of education.

Third, the community college is neither the appurtenance of the four-year college or university, nor is it controlled by the secondary education group, although in many localities it is an extension of the latter. But it stands independently, kowtowing to no other educational group.

Fourth, since one of its basic precepts is to service the educational needs of a community, it usually succeeds in enlisting the support of all facets of a community and in growing numbers secures its financial support from public funds or taxes. This, in turn, means that most newly established community colleges are virtually tuition free.

Fifth, it purports to operate more economically because it can shelter under one roof, so to speak, a variety of activities, no one of which might be operated alone with such economy. For example, it can house in a single plant a senior college preparatory course, a technical institute, a business institute, and a flexible, ever-changing evening program in so-called adult education. The argument for this sort of local educational set-up is a strong one, as many of you know from first-hand experience. Further, I'm sure that Mr. Spahr did not foresee all the implications of this developing junior college movement back in 1930 when he wrote, and I quote from his summary report:

"There is no basis in experience for expecting the junior college of a mixed character to do the work of a technical institute successfully. The junior college is in reality an extension of secondary education and its curriculum a truncated college course. Public authorities are gradually bringing the junior colleges under regulations governing

the qualifications and status of teachers similar to those which apply to high schools. The junior college of the prevailing type seeks to blend the educational theories of the mixed high school with scholastic work of a purely college type. Terminal courses of an intensive and rigorous character may in time be developed, but it is hard to see how they can fulfill the purposes contemplated in this study in an essentially secondary environment. The technical institute needs a director and staff who are in intimate touch with industry and specially proficient in blending scientific and practical instruction rather than leadership of the 'educationist' type.''

Although the position of the junior college in the field may in time develop into a serious issue, it is not the only stumbling block to continued growth of the traditional technical institute. Another problem, and one I feel to be of considerable importance, is the uncertain relationship of the technical institute to the engineering college.

The relationship of the technician to the engineer has been pretty well established as being one of mutual benefit and respect. Yet, I wonder if this same relationship exists between the technical institute and the engineering college, between the technical institute instructor and the engineering professor. This statement may seem out of place in view of the evidence just presented, especially the parts played by ECPD and the ASEE in fostering technical institute education. Yet, it seems to me that there is evidence that the technical institute has always been a stepchild, never a child; that the engineering colleges tend to provide "protective custody" but not guidance and affection; and that the engineering colleges tend to appraise results by their own academic standards, which no technical institute can meet, except as it follows the footsteps of several former technical institutes and becomes an engineering college.

Still engineering educators have a big stake in the training of qualified technicians. Thus, it would seem that if for no reasons other than selfish ones, they should face up to the problems ahead. The inadequacy and unsoundness of this relationship was recognized in the Spahr-Wickenden report, and I'm sure it is recognized today, by both engineering and technical institute educators. It is the feeling of some that this attitude of professional superiority on the part of engineering educators and of professional inferiority and inadequacy on the part of technical institute educators will be dispelled only if and when the technical institute becomes strong enough to establish a professional organization of its own. But if that day is to come, then the technical institute will need from engineering education all the respect, guidance, and filial guardianship that it can absorb, so that it might have the courage and pride to push ahead toward a goal now in sight but still encumbered by a number of problems. If I may say so, it seems that the challenge of training technicians for the years ahead is as much in the laps of the engineering educators as it is in the hands of the technical institute instructors.

Examinations for the Selection of Engineers*

By A. PEMBERTON JOHNSON

Project Director, Measurement and Guidance Project in Engineering Education, Educational Testing Service, Princeton, New Jersey

Gentlemen, it is a real privilege to talk with you about *examinations for the selection of engineers.*

In spite of the growing critical shortage of engineers, it is my belief that selection (and guidance) examinations can help materially at several educational levels to combat that shortage. My work during the last two years as Project Director of the Measurement and Guidance Project in Engineering Education, during the 3 years preceding that as Coordinator of Personnel Guidance at Purdue University and my association with engineering education since 1928 as student, graduate student, teacher, and personnel counselor suggests to me that the needs for and uses of tests at the different levels is quite different.

It is my belief that, as a group, you are primarily interested in examinations useful for engineering college freshmen. I would like first to report to you the findings of a survey undertaken last spring and tabulated too late to have been reported at the Seattle meetings of the Society. Some of you may have seen these findings in the form of a memorandum distributed last January to Deans of Engineering, Directors of Admission, and Student Counselors at Engineering Colleges through the channels of the Engineering College Administrative Council.

On April 19, 1950, Dean Ovid W. Eshbach, then Chairman of the ASEE Committee on Selection and Guidance, wrote to a number of engineering colleges requesting the names of tests used for admission and counseling freshmen engineering students. Replies from 113 colleges of engineering were received and analyzed. Through the courtesy of the Committee on Selection and Guidance and of Dean Eshbach, I am privileged to present these findings.

Certain tests are in widespread use in colleges of engineering throughout the country. More than 41% of the colleges which replied were using the American Council on Education's Psychological Examination, 39% were using the Cooperative English Test. Next most widely used tests were the Pre-Engineering Inventory and the College Entrance Examination Board Tests. Educational Testing Service is pleased that it is able to serve engineering education through these four examinations.

Frequent use of Interest tests and of Mathematics tests of a wide variety was also found.

Most Widely Used Tests Described

A brief description of the four most widely used tests follows:

(1) The ACE Psychological Examination for College Freshmen—This test is an indicator of general scholastic promise. It is slightly more predictive of success in Liberal Arts curricula than in Engineering curricula.

(2) Cooperative English Test—Higher Level—This is a carefully de-

* Presented at the Educational Methods Conference of the ASEE at its Annual Meeting in East Lansing, Michigan, June 25, 1951.

veloped and extremely popular test for measuring reading comprehension and knowledge of good English usage.

(3) Pre-Engineering Inventory—This test was developed specifically for use as an engineering freshmen selection and guidance aid and has proved very effective for these purposes. It was available prior to December 31, 1950 on a rental basis. Since January 1, 1951, the Pre-Engineering Inventory has been available on a sale basis primarily for local scoring but with ETS scoring and reporting still possible.

(4) College Entrance Examination Board (CEEB) Test—The Aptitude and Achievement examinations of the College Entrance Examination Board are administered by Educational Testing Service at 500 centers located throughout the world. These tests, highly predictive of grades in college, are the most widely used college entrance selection tests in existence. Like other entrance examinations, their greatest predictive effectiveness is realized when scores on the tests are combined with secondary school grades. This can perhaps best be shown graphically as in the chart I shall now distribute to you. (Distribute and explain the chart entitled Excellent Prediction of Scholastic Success in a Group of Five Engineering Colleges by the College Board Test Scores Combined with High School Grades.)

The Strong Vocational Interest Blank and the Kuder Preference Record (Vocational) were at 5th and 6th place in this survey of tests used in the engineering colleges for selection and guidance purposes. Seventh place was held by the Cooperative Mathematics Tests including the Intermediate Algebra, General Achievement Test, Mathematics Pretest for College Students, and the Trigonometry Test. I shall be glad to give anyone information regarding any of these tests including references to the literature.

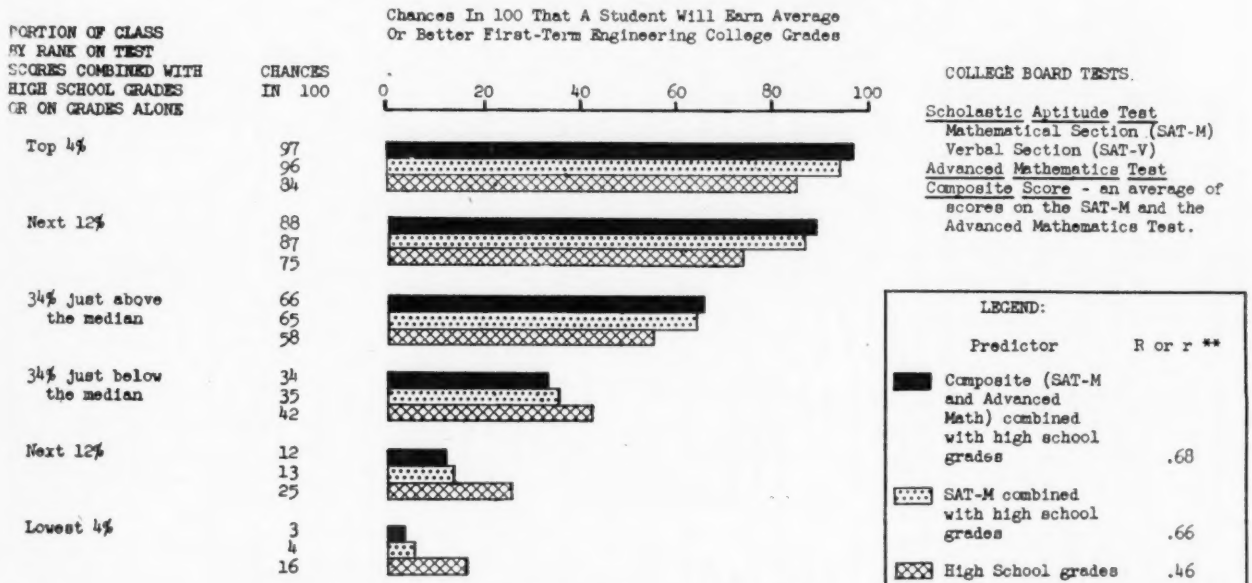
Pre-Engineering Inventory

A number of users of the Pre-Engineering Inventory are well aware of the excellent predication of first term engineering college grades which this test has consistently given. The best prediction is typically made by the composite score.

As would reasonably have been expected with the marked decline in numbers of freshmen engineering applicants, use of the Pre-Engineering Inventory has declined greatly in the last few years. One engineering educator has estimated that there may be regular facilities for as many as 55,000 freshmen in our engineering colleges while enrollments in September 1950 were only about 34,000. It became evident, therefore, that it was no longer feasible to continue indefinitely distribution of the Pre-Engineering Inventory under the rental plans. After due consideration of the matter and in order to continue to make the Pre-Engineering Inventory available to meet the needs of the engineering colleges, the joint ASEE–ECPD Advisory Council on October 22, 1950 approved the sale rather than the rental of both the short (4-hour) and the long (6-hour) forms of the Pre-Engineering Inventory beginning January 1, 1951.

At the same time, approval was given to the plan for development from the two most predictive parts of the original inventory (Comprehension of Scientific Materials and General Mathematical Ability) of a new 80-minute Pre-Engineering Ability Test which becomes available on July 1, 1951. This test is designed to meet the need for a short, inexpensive, and easily administered test which is generally quite predictive of scholastic success in engineering colleges, very nearly as predictive as composite scores on the Pre-Engineering Inventory. Norms carefully equated to the original national norms for the Pre-Engineering Inventory will be furnished so that the test can be effectively

Excellent prediction of scholastic success in a group of five engineering colleges by college board test scores combined with high school grades*



(Bars are shown at theoretical lengths - actual lengths at individual schools might differ slightly).

*Data, courtesy of Dr. W. B. Schrader, for 721 enrolled engineering freshmen tested during their first week in the Fall of 1948 at Carnegie Institute of Technology, Cornell University, Lehigh University, Rutgers University, and the University of Pennsylvania.

EDUCATIONAL TESTING SERVICE
20 Nassau Street
Princeton, New Jersey

used as soon as it is purchased. In addition, a long table of American Council on Education Psychological Examination and College Entrance Examination Board test scores comparable to Pre-Engineering Ability Test scores is furnished together with intercorrelations, means, and standard deviations for the group of freshmen at one school on which these data are based. The new 80-minute test is easily administered with separate time limits on each of the 2 parts and easily scored by counting the total number of correct responses to both parts.

Proper Use of Examinations Can Help Reduce Growing Shortage of Engineers

Because, I believe, that the proper use of examinations as far back as the 7th grade can materially help in reducing the growing shortage of engineers, I would like to speak briefly about some new developments in that area.

Last December, Professor Paul Cambreleng of Newark College of Engineering, President of the New Jersey Guidance and Personnel Association, conducted a survey among public secondary school counselors in New Jersey regarding the grade level at which consideration was given to counseling regarding the selection of college curricula. One hundred returns from over 50% of New Jersey public senior high schools and from a few private school counselors indicated that counseling regarding the selection of college curricula commonly began in the 8th and 9th grade. I have been told by some secondary school people, that it occasionally begins in the 7th grade. When we studied the matter a bit we realized that it is at the 7, 8, and 9th grade level that the prospective engineering student must begin his mathematics, science, and English sequences of courses to be ready to meet the entrance requirements of many of our engineering colleges. It is my belief that more study should be given to examining students in the 7th, 8th, and 9th grades looking to the early identification of those with the apparent interest and aptitude to prepare for and complete an engineering college curriculum. The Cooperative Mathematics Test and the Cooperative Science Test for grades 7, 8, and 9 have been found to be suitable for use with superior groups in these grades and some entire classes in the next one or two higher grades. The Cooperative General Achievement Tests, Tests of General Proficiency in the Fields of Mathematics and Natural Sciences are useful in the 10th to 12th grade range. The Cooperative English, Single Booklet Edition, Lower Level, or the separate tests of Mechanics of Expression, Effectiveness of Expression, and Reading Comprehension are useful for the 7th to the 12th grades. Other tests frequently mentioned in the New Jersey survey were the Kuder Preference Record (Vocational), the Otis Tests of Mental Ability (all forms), and the Differential Aptitude Tests. Some of the larger city school systems and certain of the state systems have developed their own programs which could be used effectively to discover potential engineering students.

For those secondary schools enrolling both English-speaking and Spanish-speaking students, the Cooperative Inter-American Tests of General Ability, Reading, Social Studies, Natural Sciences, and Language Usage with their parallel English and Spanish editions, should prove especially useful.

Selective Service College Qualification Tests

At all college levels, Selective Service College Qualification Test scores will soon be used by local selective service boards in addition to or as a substitute for rank in college class as a basis for the deferment from immediate military service of enrolled college students. We have already tested nearly 300,000 persons for the Selective Service System in this connection and other tests are to be given on June 30th and July 12th. It is our belief on the basis of rather inexact information, which was the best we could get, that an appreciable number of engineering stu-

University of Pennsylvania.

dents will be eligible in most engineering colleges for deferment on the basis of their Selective Service College Qualification Test scores.

At the sophomore level certain institutions have found the new College Transfer Test of the College Entrance Examination Board, a 3-hour morning Aptitude test, which yields a verbal and a quantitative score, to be quite useful in evaluating the ability level (exclusive of scholastic achievement) of prospective transfer students. These institutions commonly make use of the freshmen-sophomore grade record, together with a careful scrutiny of courses taken, as the best measure of scholastic achievement. Other institutions have found the Engineering Achievement Tests to be very useful indicators of achievement to date of prospective transfer applicants. A considerable potential of at least moderately well-trained transfer applicants is believed to exist in many areas.

At the college senior-prospective graduate student level, Educational Testing Service will introduce a new 3-hour engineering examination in the fall for the National Program for Graduate School Selection of the Graduate Record Examinations. This examination has a first section of 100 questions considered common to the major branches of engineering and a second section of 100 more difficult questions, 25 each in the areas of Civil Engineering, Chemical Engineering, Electrical Engineering, and Mechanical Engineering, so that the student may choose not only those 25 in any particular area in which he feels best qualified but others as well. The new aptitude tests, the profile tests, and the Advanced Tests of the Graduate Record Examinations in Chemistry, Mathematics, Physics, and 14 subject areas other than engineering, are worthy of mention.

It is my belief that, with growing knowledge of the availability of testing programs at these different levels and with recognition of the role which examinations can play in encouraging qualified persons to enter upon an engineering career, the examinations I have mentioned will increasingly prove their value to engineering educators.

In the News

Young Engineer Training Program Imminent

An organized program to aid young engineers in the first five years of professional development through the medium of a network of local committees made up of established practicing engineers is being sponsored by the **Training Committee of Engineers' Council for Professional Development.** Under the chairmanship of A. C. Monteith, Vice President in charge of Engineering and Research, Westinghouse Electric Corp., Pittsburgh, Pa., the Training Committee presented a 6-point program to aid the young engineer in the right type of training, of indoctrination, and of self-analysis.

The program presented examples of orientation and in-service training, continued college education, introduction to community service, indoctrination in characteristics, responsibilities and ethics of the profession leading to recognition through registration, self-appraisal for the purpose of orientating personal plans and of selected reading for professional and personal growth.

To implement the program the committee proposed that an extension director be employed for the purpose of organizing the resources and agencies which might help in establishing programs in a number of chosen communities. Funds are presently being raised to initiate the program.

Engineering Design as Related to Research*

By Forest McFarland

Chief Engineer, Design and Research Division, Packard Motor Car Company

In considering the subjects covered by the title, the first questions which might well be asked are, "What is Design?", and, "What is Research?". Webster states that design is "the production of a scheme or plan for the making of anything." This is certainly a definition in its briefest form. He also states that research is "careful or critical inquiry or examination in seeking facts or principles." This is likewise brief and broad.

Many definitions have been offered to explain the meaning of research. None is entirely adequate. From the standpoint of final result, the statement that "research has been called insurance against capital loss" is significant. Rather than attempt to define design or research further, a few examples will be given to illustrate these two functions of engineering and their relationship.

What can we classify as design in a broad sense? What is its history? When did designing start?

Excavation by Sir Arthur Evans on the Island of Crete revealed the remains of the Neolithic or Later Stone Age culture which reached back 13,000 or 14,000 years. Man's real design and construction effort, however, could not begin until he ceased to wander in search of a precarious livelihood.

What examples do we find of early design? According to M. C. Burkett, Lecturer of Archaeology and Anthropology at Cambridge University, the oldest known wheeled vehicle was discovered at Kisch, the world's oldest city, and was built about 3200 B.C.

Much has been written about the structures erected by the Egyptians, Greeks, and Romans throughout the centuries following, the last two periods being marvelous eras of unsurpassed architectural design.

After the fall of Rome, architectural design of a grand order disappeared in Europe and western Asia until the Middle Ages when the building of cathedrals and monasteries again revived it. Design of a more mechanical nature began to appear. Time keepers are one interesting and common example of design of this type. Starting with the sun dial, apparently used as early as 2000 B.C. in the valleys of the Tigris and Euphrates, we next come upon the Clepsydra or Greek water clock invented by Ctesibius at Alexandria in the second century B.C. Sand took the place of water in many clocks, one variation being the 28-second sand glass used for a long time for determining the number of knots or nautical miles per hour covered by a vessel. The origin of the first design of mechanical clock is somewhat in doubt, but in 1360 there was evidence of at least one mechanical clock designed by Henry Weeck, or Henry DeVick as afterward called, of Wurtemburg, for Charles V of France. Clock and watch designs appeared in many forms finally developing into those which we have today. Space prevents mentioning many more examples of design, such as the works of Leonardo de

* Presented at ASEE Summer School for Engineering Drawing Teachers at East Lansing, Michigan, June 26, 1951.

Vinci, Cellini, and other marvelous craftsmen with whom we are all familiar.

History of Research

What was occurring in research, taking it in its broadest sense, over this period of time?

In Egypt the practice of preserving the bodies of the dead by mummification has excited the wonder of mankind for ages. G. Elliott, Professor of Anatomy, University of London, states this practice extended over at least thirty-five centuries and that it underwent an unbroken series of different techniques. That I would call a "long term" research project.

One example of a very complete report on early investigations came to my attention a number of years ago in a curious way. In the mathematical analysis of a problem, I came across a proposition in plane geometry with which I was unacquainted. This aroused my curiosity. As I needed a new geometry reference book, I journeyed to the Detroit Public Library and surveyed all the works available and found one by Sir Thomas Heath, in three volumes, which was very complete—a new translation taking into account all of the information unearthed since previous translations had been made. I found the proposition that had been new to me, and discovered that the geometry taught me in high school was from a very much abridged edition of the complete works compiled by Euclid in thirteen books to cover the information available 300 years B.C.

De Morgan, the British mathematician, stated in 1848, "There never has been, and till we see it we never shall believe that there can be, a system of geometry worthy of the name, which has any material departures (we do not speak of corrections or extensions or developments) from the plan laid down by Euclid." Heath states that had De Morgan lived at that time (1925) he would still be of the same mind. The fact that this work has lived for twenty-two centuries without any revisions or significant additions marks it as being an investigation and summary of the highest order. The elegance of the propositions in their simplicity and choice of language commands further respect and should cause all of us to reappraise some of our contributions in the light of that from which we have had to draw.

The history of design in clocks was mentioned. Prof. W. I. Milham, in his book, "Time and Timekeepers," states that since 1368 when the pendulum was introduced into the clock mechanism, there have probably been nearly three hundred different designs of escapements experimented upon and nearly one hundred escapement designs for watches. So we realize the designs of our modern mechanical clocks and watches are the result of an enormous amount of investigations and tests.

We could list many investigations made over the centuries labeled as discoveries, developments, and so on, from the wealth of material available. Two or three examples were touched upon to stress the point that design and research are by no means items peculiar to the last half century or so.

Relationship of Contemporary Design to Research

In considering the relationship of contemporary design to research, there are two broad phases which are diametrically opposed which immediately come to mind. The first is where designs are partially developed and to be completed must wait for research work to permit their completion. The second phase is where "long term" research develops products which are eagerly seized upon by designers after they are introduced and often used in many forms never anticipated by those who developed the product.

Let us consider the first phase, particularly in the automotive field and aircraft engine field in which the writer is best acquainted.

For many years we have all been trying to make automatic transmissions for cars that would do a better job than the hand

shift mechanism. In the minds of some of us for a long time and over the last ten years in particular, the idea has been present that a better design could be evolved if the torque converter invented by Fottinger in 1906 could be made acceptable for passenger car use. This has resulted in our designs being held up, so to speak, until sufficient research work was done to give assurance that this element could be included in the design. This work has resulted in four distinct and different combinations being in production today. We have them because the research work on the product indicated four answers, all of them acceptable commercially.

Another example of design waiting for research is in stress determination. During the last war, test experience disclosed a weakness in an existing design of blade connecting rods in an aircraft engine manufactured by the company with which the writer is associated. A Stresscoat, or brittle lacquer investigation, showed a highly stressed point which was greatly reduced by removing metal from the existing design. Test results confirmed the findings and approximately one-quarter million dollars worth of blade rods were saved by reworking the existing rods. This is clearly a case of design "waiting" for research.

Another example which the writer has cited is in regard to surface finish on the cam followers of the same engine on which a smooth honed finish was discontinued, using the ground finish only, present before the honing. This procedure eliminated approximately ninety per cent of the scuffing of the followers, present with the original finish. Another case of design waiting for research for improvement. This particular item points out one highly significant fact in engineering design—that the parts themselves will tell you what operating conditions they like or what is "good" or not, which may well be at variance with certain theories not based on facts. This leads to the moral that one must have an open mind at all times until competent testing reveals the facts.

Another example of design waiting for research was in the development of the transmission brought out by the writer's company two years ago.

The direct clutch and torque converter assembly had a combination of members, all of which were Stresscoated with brittle lacquer and spun at a series of increasing speeds to determine the highly stressed points. A considerable number of design changes were made to reduce these stress raisers and a final check was made by bursting all of the parts involved.

Many more examples could be given to show that design must wait for investigation or research before it can proceed safely. This is one of the biggest unknowns in attempting to "time" the commercial introduction of basically new designs.

Research Covers a Broad Field

I may be challenged by some for including some of these examples as research. My only answer is that present research covers a very broad field. We have all heard much about the new nuclear research. Most of us, however, have not heard of and do not realize the vast amount of manufacturing research that is going on. One other example is the work of Dr. Hans Ernst with the Cincinnati Milling Machine Co., on the actual behavior of the metal in the cutting process. His exceptionally clear high-speed movies show that ordinary chip removal is definitely a shearing process at a well established angle instead of being a "paring" process as pictured in many illustrations for years. This is a definite contribution to our knowledge of a process used for centuries.

Let us take the other side of this picture where designers use the products of research. This can probably be illustrated best by a number of examples.

In the early Thirties, the writer had occasion to work on the development of the first rubber crankshaft vibration

damper used by our company on passenger car engines. Our tests had shown that there must be a combination of an elastic coupling and friction present between the damper flywheel and the crankshaft. Our tests also showed that rubber had no friction present of commercial value. This resulted in our employing friction discs in addition to the rubber elastic coupling. If we were to design this damper today, we would have available rubber "loaded" with certain compounds that would add friction to it or give a "hysteresis loop" of sizable value so we would doubtless eliminate the friction plates. However, research has also brought another party into this picture—silicone fluids of constant high viscosity which are now used in dampers, eliminating the mechanical friction materials and rubber, also. In our early work we had visualized how nice it would be to mount a flywheel in a casing only but knew the oils we were acquainted with would change too much in viscosity to be commercial.

The development of plastics has made designs possible that could not be considered a few years ago. Gears can now be molded from nylon at a fraction of the cost of cutting them. For many purposes the nylon gears are superior to the metal gears. This is only one of many uses plastics are being put to.

The DuPont Company has just completed an experimental station for fundamental research, built over the last three years at a cost of 30 million dollars. DuPont defines scientific research as "a critical investigation in the physical sciences directed to discovery of new knowledge." The company divides research into three categories: Improvement in existing processes and products; development of new ones; and fundamental research to uncover new knowledge without regard to specific commercial objectives. DuPont says it does research because it has to. This can be well understood when we realize that more than half of the company's sales in 1950 were in products either unknown or in their commercial infancy twenty years ago.

In thinking about the relationship between design and research, one thing always comes to my mind—that is the importance of proper analysis of the design in the light of what it is to accomplish. I have seen a goodly number of designs that were not operable which could have been "saved" or made to operate by being properly analyzed and the indicated steps taken to correct the design. There is no function in engineering design or development that pays off so well for the effort expended.

Importance of Fundamentals

To properly and efficiently analyze designs, the young engineer should know his fundamentals well, not just have a speaking acquaintance "with" or "of" them. I found my own collegiate education lacking in elementary mathematics, kinematics, advanced mechanics, particularly in vibrations and some other courses. I feel my own collegiate education would have been more valuable had more time been spent on the fundamentals of all the sciences and less on general reading courses. After the student has finished his formal or "official" education, he has to read and glean information all his life anyway. The time spent at college can be used best in equipping him with the "best" tools possible for his future use.

What must industry have, to be willing to finance research on a long-term basis particularly to yield products that designers or others may use? Industry must be able to reap a fair reward for promoting many projects, most of which will not pay out as it is only a gleaning of the many projects that finally becomes one of the future products of the company. Over a period of time, engineers and others will thrive only as the organization they are in thrives. We each have a personal responsibility to do our bit toward keeping our economic and governmental structure on a sound basis. That permits and encourages companies to extend them-

selves research-wise with reasonable rewards possible for developing new and better products.

Individual Freedom Necessary

Companies and individuals must continue to operate in an atmosphere where individual freedom continues to encourage research and design so they will continue for the benefit of the many, and will result in the satisfaction of creativeness in the individuals engaged in the work which is one of the major dividends to them.

I hope these few brief remarks and examples will serve in a small way to demonstrate how research and design work together and under what conditions they can operate most effectively.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

B. L. WELLMAN, *Editor*
Worcester Polytechnic Institute

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Mid-Winter in New York

By M. B. LAGAARD

Chairman, Engineering Drawing, Northwestern University

and

B. L. WELLMAN

Professor of Mechanical Engineering, Worcester Polytechnic Institute

The Mid-Winter Meeting of the Engineering Drawing Division, which was held in New York on January 23rd to 25th, will be long remembered by those who attended. Members of the host institutions, Columbia University, The Cooper Union, and the U. S. Military Academy are to be congratulated for their well planned program.

The Cooper Union was our host on the first day. Following a tour of their historic Foundation Building, Mr. Renato P. Iodice presented a paper on the application of descriptive geometry in shipbuilding. The content of his talk was carefully designed to lay the groundwork for our afternoon visit to the Mold Loft of the New York Naval Shipyard. There Lt. W. J. Dixon demonstrated with the aid of two loftsmen the development of a shell plate of a ship. The work was carried out in detail from the given frame lines of the ship to the actual layout on the loft floor of the full-size paper template. The tour through the ship-fitters shop showed how the massive plates are cut, beveled, drilled, and rolled to proper shape.

Columbia University entertained us on Friday. In the morning session the announced paper by Mr. Lloyd E. Varden on photographic processes was followed by two others. Professor L. R. Schruben of the University of Southern California spoke on the relations of the engineering freshman to his drawing instructor, and Professor H. B. Howe of Rensselaer Polytechnic Institute described some of the statistical research methods he has used to test his teaching procedures in drawing and descriptive geometry. After the luncheon and business meeting the afternoon was devoted to inspection trips.

No greater substantiation of the fact that drawing is a basic and fundamental part of all engineering could be found than in the curriculum at West Point, where the same organization that trains the man also employs him after he graduates. The thoroughness with which they cover the field of drawing is ample evidence of the importance they attach to it.

(*Continued on page 372*)

Improvement of Cooperation Between Industrial Engineering Faculty and Industry *

By ROBERT T. BORTH

Manager, Community Relations, Employee Relations Division, General Electric Company

I am indeed grateful for the opportunity to appear before you distinguished educators today—and for a three-fold reason: First, because I am directly concerned with industrial relations—struggling daily with its problems in the General Electric Company—and I come to you for help, and advice. Second, because so much of the future progress of the American free competitive enterprise system (our profit or loss system) depends upon our success in the area of industrial relations—on the pursuit of job satisfaction for the 60 million people of our working force, and upon their acceptance of ever greater technological advancement in arm-lengthening tools. I welcome always an opportunity to help expand the horizons of our industrial thinking. And third, because you, in the field of education, can accomplish so much in the development of sound-thinking economically-statesmanlike future leaders in our businesses and professions. We in industry welcome any opportunity to discuss our growing problems with you— problems which we must solve together.

Perplexing Problems

Believe me, I appear before you today in sincere humbleness—nothing quite so humbles all of us businessmen as failure in the midst of success. Mr. Lee of Standard Brands put it quite clearly in a talk a couple of weeks ago when he said: "The people will go into the stores and vote for your products by purchasing them, and then go to the polls and vote you out of business."

We business men, we like to think, are people of the highest ability, the best intentions, and the architects of the greatest standard of living in history—both as to material and spiritual well being. We are great physicists, chemists, engineers. We are phenomenal manufacturers. We have been fabulous financiers. We are superb in individual selling and mass marketing.

Yet, as the whole man of business—the manager and leader—we are condemned. When we try to merchandise the overall economic and social consequences of our operations, we fail. In fact, it has become the habit of many politicians to believe that the way to *sure* election is to promise, the correction of our "wicked abuses," to our employees and the public. This is a successful habit not just of cheap and ill-mannered politicians, but of those of the most impeccable backgrounds of family and education.

People like—and respect—the results of our separate professional skills. But taken as a whole, our activities seemingly are regarded by a majority of the public as anti-social.

How do we find ourselves in this situation? With our customers, stockholders, and vendors approving of us, to be sure. But with our employees and their allies—the unions, the government, too often the clergy, too much of the public—in other

* Presented before the Industrial Engineering Division at the Annual Meeting of the ASEE, Troy, N. Y., June 22, 1949.

words our real bosses—not only not respecting and liking us, or even appreciating or understanding us, but even not crediting us with good intentions—with being on their side—by which we mean being on the side of what's good for all.

People are led to believe that the jobs we provide are not what they ought to be. They are led to believe that the economic and social consequences of our activities, and the system back of our activities, are not what they ought to be for the good of each community and of the nation. They think that we are smart, skilled, technically honest, but coldly selfish and not on the side of employees and the public.

As a result, they not only do not *seek* our participation in important affairs, in the running of the country—but in many fields they don't *permit* it—and we are largely ruled out of councils as undesirables. Yet we are the same people who give largely those same people the products and prices they like in the individual cases, in the direct or indirect investment safety and return they have liked.

What can be the matter? What ought to be done? And who ought to do it? We, at General Electric, think it is largely the job of business. But you educators can be a tremendous help.

At G. E.—where we have all these questions—we decided two years ago that we, at least, would have to try to do something about it, and that we certainly must not continue to take these puzzling problems lying down—or go on about our customary pursuits being technically successful while failing in the larger and the only really important sphere of true personal accomplishment and real social usefulness.

The Approach

We determined to try to draw on our sales and general management experience to determine what were all the things which we did to make us successful in the product sales field but which we were not doing in the job customer and community relations field.

Using typical market research to learn the likes and dislikes of our employees and then employing product planning methods, we determined that our first job was to have us all in management—that includes foremen—work toward giving each employee a new model job with nine specific features the employees had said they wanted.

Our approach toward this 9-point, new-model job was along three lines.

(1) Getting and keeping the pay, working conditions, and other material characteristics of each job up to the ever-rising standards in these respects—VOLUNTARILY.

(2) Getting supervisors at all levels to establish genuine and continuous and intimate two-way communication with each employee—to respect his dignity, supply him with desired information, give him a real sense of importance and participation,—and act like salesmen instead of bosses, getting the employee to want to do what's wanted and not in any sense be driven to do so.

(3) We think we have found that even if the employee—or his family and neighbors—feel he has got the best pay, best working conditions, and best boss in town—if he feels his boss and company have been literally "born again" and are on his side, and are really putting human considerations first—it still isn't enough.

And right here we run into what I think is the most colossal and the most pressing problem of our times. We know, for instance, how to price our jobs and how to be the salesmen to sell and satisfactorily serve our job customers—and we only need to transfer to that area the skills we have developed in our product marketing departments.

But we have few skills in this third area. Few of us know, or can put convincingly in words of one syllable, the reasons why our profits are not the reason for high

prices as the left-wingers charge. Too few of us really know our economics—the relationship of wages, prices, taxes, and profits and loss—the function of savings and of investment in technological advances—the social gains of incentives and competition in a free market of millions of individual decisions versus central planning—how we can and do raise our real wages, our real standard of living—how we get into a disinflation like the present, and how we can get through it and come out into a healthy, steady era of sound business instead of another silly and debilitating spree.

Futility of Passive Resistance

Why is it so frightening for businessmen, employees, all serious and patriotic citizens not to know—and not to be teaching and discussing sound economics and good sensible political conduct?

It's because of this new kind of robber barons that have gotten more and more successful elsewhere out around the world during the last 30 years. They always first get themselves outwardly cloaked in the mantle of the common man. But their objective is power—and power direct rather than through money. Their methods are therefore political and not commercial (which is where our ability is).

Businessmen, unthinkingly continue to devote themselves purely to the customary commercial pursuits, have meanwhile in country after country been gradually weakened and then displaced. Along with their displacement went freedom—for all the people—freedom and any hope of human dignity, plenty, and the good life.

After seeing this at work abroad among our enemies and our allies alike for thirty years, what do we find ourselves doing? We rich Americans, whose so-called "ill-fed, ill-housed, and ill-clothed lower third" are so well off that they are the envy of the rest of the world! We natively smart Americans, who not only have fine basic education but have had others' experience enacted right before us so we don't have to theorize or experiment or take any foolish chances!!

How are we acting? What are we doing?

First, we are putting on a great spectacle of how sorry we are for ourselves. Our plight seems indeed tragic. We only treated ourselves to one million new homes last year—4½ million refrigerators—almost 5 million motor vehicles, on top of about 38 million already on wheels at the beginning of the year. We right now—with the possibility of some overdue readjustment looking us in the face—still seem to be making progress toward going out and getting in each other's way with another 4 or 5 million cars this year.

Second, we had all these new things and all these savings left after handing over taxes to our federal government at a rate of over $40 billion a year. And get this picture! Half of this $40 billion of taxes is being spent to ward off the foreign Communist menace to our system and safety, while right at the same time here at home too many of us in and out of government and unions and business are joyously, if not hysterically, embracing one after another of the very ideas, influences, features, or ingredients of collectivism (or communism with a small "c") that can surely lead us off the deep end into the same type of police state we so fear—the very police state of poverty, slavery, and hopelessness we are fighting with our billions to prevent from happening elsewhere.

What do we have to do to be saved, then? It seems to me all we have to do is just to do exactly as we do when we encounter any other unsound or unfair salesman out trying to compete for our customer's favor. We take a good look at our product, make certain again that it's right in function and price for the current market, and then go out to sell the daylights right out of the something-for-nothing boys.

Responsibilities of Citizenship

A distinguished M.I.T. professor told me in New York last week that he was beginning to believe that the missing in-

gredient in employee relations and community relations was summed up in the one word "politics"—or political action by manager, stockholders, bondholders, insurance policy holders, savings bank depositors, pensioners, and others with an interest in keeping the value of money honest, the standard of living rising, and the freedom of choice, speech and movement really free.

I would agree if he meant by political activity the mastery of sound economics and the insistence by citizens on sound economic teaching and practices by their representatives in government, in unions, even in the clergy, as well as in business.

Those who have been in Washington recently will know already that, while there is a selling job to be done there, the primary selling job must be done at the grass roots. The Senators and Congressmen are like furniture buyers sent to the annual market with not much leeway for their own discretion or taste. They do—and are supposed to do—what the folks back home want done.

Who is to do something about all these things? Who is to keep on—in the critical days ahead—talking to his Congressmen and friends about proper legislation in the public interest? Who is to learn, and then teach economics? Who is to put his citizenship duties ahead of his commercial duties?

I can't speak for others, but I can tell you it is the individual conviction of member after member of the force of 15,00 in G–E management not to look to others or to try to delegate this job of good citizenship to subordinates or to associations—but to do this job ourselves. Each one of us to the degree we can attain the personal facility and command the interest of others in the things we are trying to do in the public interest.

Many of us have seen—are seeing and writing—our Congressmen and Senators. We have testified on pending legislation before House and Senate Committees. We are telling our neighbors back at the grass roots what we think. We are learning economics and teaching economics to our supervision, our 200 thousand employees, our 7 million neighbors in our plant cities. We are discussing in print every controversial public issue that involves job-connected economics or public policy effect on us, our employees, or our neighbors.

I have outlined for you what we are trying to do in this wide area of industrial relations. Many other concerns facing the same problems are following a similar course, or a different course toward the same objectives.

Staving off the Tide

You gentlemen might well encourage and abet this trend toward the main essential—economics. Not only should students absorb all the economics they can but it would be wonderful if upon graduation they were equipped to be economic teachers. I mean by that not only to be equipped as teachers in the formal sense but as teachers who are able to debate the theories and practices of economics with tough and facile opposition over the radio, on television, at women's clubs, church meetings, and public meetings of all kinds. If we ever are going to be able to understand fully this wonderful system of ours, we have got to have a sort of "town meeting" going on constantly wherever citizens meet, from groups of two on up, and to lead such discussions we need sound students of economics.

You gentlemen could help too, in the various projects that are going on around the country now in the organization and conduct of adult economics courses. In this connection I would like to tell you something of what we in General Electric have done to encourage such adult economics courses. In Schenectady, last autumn, we assisted the Lions Club there in arranging a discussion course whereby members of a panel, led by a trained instructor, sat upon a stage in an auditorium and through discussion developed the theories of sound economics and applied them to their day-to-day operation. Subscribers included businessmen, union leaders, the clergy, and professional people

who sat in the audience and listened to the discussion going on on stage. The course was entitled "What Every Man Should Know About Business." This was entirely an experimental proposition but it was so well received that we circulated reports of it across a wide segment of our friends and contemporaries around the country. Since that time similar courses have been held elsewhere. In my own home city of Syracuse, the Citizens' Foundation conducted the course and drew a sell-out crowd of 700 throughout the full 13 weeks that it ran. Attendance was entirely voluntary and was paid for, by the most part, by the individuals attending. These people were happy to give up one night a week to learning fundamentals of our economic system.

At Grand Rapids, Michigan, I understand the course has had similar success and plans are underway now to continue the course at Worcester, Mass., and Bridgeport, Connecticut, and half a dozen other cities around the country. Hardly a day goes by but what we in General Electric receive queries about the success of the course and how it was conducted. This is a third area where you gentlemen might well indeed assist business in improving industrial relations.

What I think we all ought to do to contribute to the understanding, the preservation, and the improvement of our free and wonderfully productive system of incentives and competition are as follows:

(1) Before anything else we have got to be born again (and you can help in that rebirth). We have got to shake a life-time's habit of mind about values.

(2) We have got, of course, to provide good jobs and good bosses (and in the latter sphere you again can help us). And we have got to have this known to our employees, to their neighbors, and to the whole public.

(3) Then we come to this larger job itself. That's the job of deserving and getting a favorable economic climate for our operations, and then deserving and getting favorable recognition for the overall economic and social consequences of the way we have embraced this opportunity.

But it's got to be done if business management—in fact our free system—is to survive. I think it can be done if we will recognize and do something about it.

But businessmen need your help. We need your help to make more of us —and those to follow us—understand this wonderful system of ours—help to learn how to preserve and improve it rather than let it be damaged, or even perish. We need your help in seeing that a majority of citizens understand the economic facts of life, the proper working of our system, and the fallacy of all these contrary something-for-nothing fairy tales. With your help—and with similar help from educators everywhere—I feel sure that the bridge of industrial relations, the lifeline of our great free competitive enterprise system, will be a lasting and monumental edifice which will not and cannot be torn down!

An Employment Survey of Industrial Engineering Graduates of the Pennsylvania State College*

By GEORGE L. THUERING

Assistant Professor, Department of Industrial Engineering, The Pennsylvania State College

The first curriculum in Industrial Engineering in this country was started at The Pennsylvania State College in 1908, some 43 years ago. Upon the occasion of its fortieth anniversary in 1948 the Department felt that it would be appropriate if it undertook a study of its graduates to determine what they were doing and how they had fared since graduation.

The Department graduated its first two students in 1910. From 1910 through 1948, the period covered by this survey, 1051 students were graduated. In the two years since 1948 another 315 have received degrees in industrial engineering. As one might expect, during the early years the graduating classes were small and averaged about 10 men per year. Following World War I and coinciding with the "Efficiency Expert" era of industrial engineering, enrollment climbed and an average of 35 men per year received degrees. From 1925 through 1938 enrollment was fairly stable. Graduating classes averaged 21 per year with a high of 29 in 1927 and a low of 15 in 1933. The period of stability ended with the class of 1939, and a period of growth began. This growth, which actually started with the freshman class of 1935, was interrupted in 1944, 1945 and 1946 by the war, and was greatly accelerated by returning veterans in recent years. This year (1951) approximately 90 degrees will be granted, a drop from the maximum of 164 degrees granted in 1949.

Method

The survey of the alumni was conducted by mail. It was possible to contact 880 of the 1051 graduates of the years 1910 through 1948, and replies were received from 615. This represented 51.8 per cent of all graduates or approximately 70 per cent of those contacted.

The replies were grouped and reported by five-year intervals starting with 1911. The one exception was the most recent group which contained the three years of

TABLE 1

COMPARISON OF NUMBER OF GRADUATES AND NUMBER OF REPLIES TO QUESTIONNAIRE

Years	Graduates	Replies	Per Cent Replies
1946–48	209	149	71.3%
1941–45	192	120	62.5%
1936–40	167	108	64.6%
1931–35	100	58	58.0%
1926–30	114	69	60.5%
1921–25	173	72	41.6%
1916–20	61	29	47.5%
1911–15	33	6	18.2%
1910	2	0	—
Totals	1051	615	58.1%

* Presented at the 59th Annual Meeting of The American Society for Engineering Education, at Michigan State College, East Lansing, Michigan, June 25–29, 1951.

1946, 1947 and 1948. This grouping was decided upon as it was felt that a graduate's age, or the era in which he graduated, might have some influence on his work. It was also felt that the smaller number of replies from older graduates would be lost among the large number of replies from more recent and also considerably larger graduating classes. In a further attempt to facilitate comparison and reduce misunderstanding all results were reported in percentages of replies.

Results of Survey

A summary of the number of graduates and number of replies is given in Table 1. As one would expect, a greater percentage of replies was received from the more recent graduates. The highest percentage, 71.3 per cent, came from the 1946 through 1948 group and the lowest, 18.2 per cent, from the 1911 through 1915 group.

When the replies were analyzed, it was found that graduates were in a wide range of industries and in a variety of occupations in these industries. Table 2 shows the percentage distribution of graduates according to industrial fields.

Seventy-two per cent of all graduates were employed in the major industrial field of manufacturing. The 1941 through 1945 group with 78.3 per cent had the

TABLE 2

PERCENTAGE DISTRIBUTION OF GRADUATES BY INDUSTRIAL FIELDS IN WHICH EMPLOYED AND YEAR GRADUATED *

	Total	1946–48	1941–45	1936–40	1931–35	1926–30	1921–25	1916–20	1911–15
Agriculture and Forestry	.3	—	.8	—	—	—	—	—	—
Mining	.3	—	.8	—	—	1.4	1.4	—	—
Construction	.7	.7	.8	—	1.7	1.4	—	—	—
Manufacturing	72.0	75.2	78.3	77.8	76.0	69.5	54.2	55.2	33.3
Food and Kindred Products	2.6	2.0	2.5	2.8	3.5	4.3	—	6.9	—
Textile Mill Products†	3.3	3.4	1.7	8.3	3.5	1.4	1.4	—	—
Lumber, Furniture and Lumber Products	1.3	1.3	—	1.9	—	1.4	4.2	—	—
Paper and Allied Products	2.0	2.7	1.7	2.8	1.7	1.4	1.4	—	—
Printing and Publishing	.8	.7	—	—	1.7	2.9	1.4	—	—
Chemicals and Allied Products including Rayon	3.9	4.0	2.5	5.6	8.6	5.8	—	—	—
Petroleum and Coal Products	5.6	5.3	3.3	4.7	6.9	10.1	7.0	6.9	—
Iron and Steel and Their Products	12.5	14.7	14.2	15.8	3.5	7.2	11.2	13.7	16.7
Machinery	28.8	33.6	42.5	22.2	34.5	17.4	19.4	13.8	16.7
Transportation Equipment	3.3	2.6	3.3	6.6	5.2	2.9	—	—	—
Other Manufacturing Industries‡	7.7	4.7	6.7	7.4	6.9	14.5	8.3	13.8	—
Transportation	.8	—	.8	—	1.7	2.8	—	—	—
Communication	1.5	3.4	—	—	—	2.9	2.8	—	—
Utilities	1.6	1.3	2.5	.9	—	1.4	4.2	—	—
Other Industry Fields (Service)	17.9	12.8	9.2	19.5	19.0	14.5	29.2	41.4	66.7
Any Field Not Specified	2.5	2.0	.8	—	1.7	5.8	6.9	3.4	—
Unemployed	.8	1.3	1.7	—	—	—	1.4	—	—
Student	1.3	2.0	3.3	.9	—	—	—	—	—
Wife	.5	.7	.8	.9	—	—	—	—	—

* Adapted with some deletions and additions from the list in "The Engineering Profession in Transition," A Report of The Engineers Joint Council on the 1946 Survey of the Engineering Profession, prepared by Andrew Fraser. Page 71, Engineers Joint Council, New York.

† Including clothing but excluding rayon.

‡ A large part of this consists of companies manufacturing insulating, roofing and floor covering materials.

TABLE 3

PERCENTAGE DISTRIBUTION OF GRADUATES BY OCCUPATION (FUNCTION) AND YEAR GRADUATED

	Total	1946–48	1941–45	1936–40	1931–35	1926–30	1921–25	1916–20	1911–15
Sales*	15.4	17.5	16.7	13.9	10.3	10.1	19.5	17.2	16.7
Consultant	2.0	—	—	4.6	5.2	1.5	1.4	6.9	—
Own Business, Partner or Officer†	11.3	2.7	5.8	6.5	15.5	26.1	20.8	27.6	16.7
Technical Engineering	7.9	4.0	10.0	8.3	13.8	4.4	11.1	3.5	16.7
Manufacturing (Line)	9.2	4.7	10.8	9.3	12.1	16.0	8.3	6.9	—
Manufacturing (Staff)	42.2	50.4	47.5	57.5	39.7	36.2	25.0	13.8	—
Methods and Planning	6.9	10.7	8.3	11.1	5.2	1.5	—	—	—
Time and Motion	6.1	11.4	9.2	7.4	—	—	1.4	—	—
Costs	2.5	2.7	1.7	5.6	1.7	1.5	1.4	—	—
Coordination	3.3	2.7	5.0	3.7	3.5	1.5	1.4	6.9	—
Personnel	3.6	2.0	1.7	5.6	10.3	7.3	1.4	—	—
General Industrial Engineering	11.4	12.8	15.0	12.0	12.1	11.6	4.2	6.9	—
Other	8.5	8.1	6.7	7.4	6.9	13.0	15.3	—	—
Other	12.1	20.8	9.2	5.6	3.5	5.8	13.9	24.1	50.0

* Sales and sales engineering, does not include self-employed sales representatives.
† All self-employed, including self-employed sales representatives.

highest percentage in this field. Of the specific industries within the field of manufacturing, the machinery industry with 28.8 per cent and the iron and steel industry with 12.5 per cent employed the greatest number of graduates. These percentages are similar to but slightly higher than those obtained for Mechanical-Industrial Engineers in a nation-wide survey conducted in 1946. In the 1946 survey 65.6 per cent were in manufacturing, 11.2 per cent in iron and steel, and 22.4 per cent in machinery manufacturing.[1]

Of the remaining 28 per cent of the graduates who were not in manufacturing more than half were in service type activities. Service type work which included wholesale and retail trade, education, government service and similar activities employed 17.8 per cent of all graduates.

The only significant trend by years was a decrease in the percentage of older graduates in manufacturing and a corresponding increase in the proportion in service type work.

As a further aid to analysis Table 3 was prepared. This tabulation shows the distribution of graduates by occupation (function). Manufacturing (staff) positions were held by 42.2 per cent of all graduates with the second largest percentage, 15.4 per cent, in sales. The next three occupations in order of importance were own business, manufacturing (line), and technical engineering. Only 2 per cent were working as consultants or employed by consulting firms. As one would expect, the percentage of graduates who owned their own business or were partners or officers in corporations increased with an increase in age. Offsetting this was a decrease in the percentage of older graduates holding manufacturing (staff) positions.

A comparison of the data in Table 3 and similar data presented in a study of all engineers by The American Society for Engineering Education in the 1920's is interesting.[2] In the 1920 study it was

[1] "The Engineering Profession in Transition," A Report of The Engineers Joint Council of the 1946 Survey of the Engineering Profession, prepared by Andrew Fraser, page 87, Engineers Joint Council, New York.

[2] "Report of the Investigation of Engineering Education 1923–1929," Fig. 2, page 232, Volume I.

discovered that immediately after graduating 71.2 per cent of the engineering graduates were doing work that was primarily technical, and 28.8 per cent were doing work that was primarily administrative. However, among the graduates with more than fifteen years experience (fifteen to forty years experience) only 30.5 per cent were doing technical work, and 69.5 per cent were doing work that was primarily administrative.

If one considers as the 1920 study did the fields of sales, own business, manufacturing (line), and manufacturing (staff) in Table 3 to be primarily administrative work, and the field of technical engineering to be primarily technical, the following percentages result:

	Primarily Technical Work	Primarily Administrative Work
1916–20	3.5%	65.5%
1921–25	11.1%	73.6%
1926–30	4.4%	88.4%
1931–35	13.8%	77.6%
1936–40	8.3%	77.0%
1941–45	10.0%	81.1%
1946–48	4.4%	75.3%

This tabulation shows that the overwhelming majority of the graduates started in primarily administrative work and remained in that type of work. The percentage in primarily technical work was small and did not change with age or experience.

Summary

The findings of the survey can be summarized as follows:

1. Seventy-two per cent of all graduates were employed in manufacturing industries. More than half of this group was in iron, steel and machinery manufacturing.
2. The remaining 28 per cent of the graduates were employed in a great variety of industries and businesses with the majority in service type activities.
3. From the standpoint of occupational activity, 78.1 per cent were doing primarily administrative work. The largest single percentage, 42.3 per cent, had manufacturing (staff) positions with the next largest group, 15.4 per cent, in sales.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

TIMELY TIPS

(Papers submitted for TIMELY TIPS *should not exceed 3 pages of typewritten, double-spaced material, including any mathematical formulas, and should contain not more than 2 illustrations.)*

The Questionability of Questionnaires

By ARTHUR M. HILL

Head, Mechanical Engineering Department, Tulane University

The questionnaire is a popular device for obtaining information on specific subjects. However, more thought might be given to the convenience of the person receiving it.

First, a self-addressed and stamped envelope should be enclosed.

Second, the mimeographed blank for answers should include the name and address of the originator of the questionnaire.

Third, date all questionnaires. It is just good engineering practice to date material and it might serve to jog the recipient into a reasonably prompt reply.

Fourth, before deciding on final form, try out the questionnaire on a fellow faculty member, preferably one who comes from a university outside of your community. Too often questions may seem clear to the writer, but will appear vague to others.

Fifth, remember that answering is time consuming; keep the questions to a minimum number.

Deflections by Euler's Double Integration Method

By G. SONNEMANN

Assistant Professor of Aeronautical Engineering, Drexel Institute of Technology

Professor M. W. Jackson clarified in his recent article* the relation between the Virtual Work, Dummy Load, Conjugate Beam, and Area Moment method for computing the deflections of a beam. The Euler Double Integration Method should also be clarified, or better, be simplified.

The inherent difficulty with the Euler Double Integration Method as presently taught in most schools is the great number of constants that have to be evaluated in any given problem. This basic difficulty can be readily overcome and one can reduce *any* elementary strength of material problem to one in which only *one* constant has to be evaluated. It can be readily seen that under those circumstances the Euler Double Integration Method becomes a more convenient method than the area moment method.

In brief one has the following consideration. Examination of Fig. 1 shows that the distributed load stops at point B.

* *Journal of Engineering Education*, October, 1951; Vol. 42, No. 2, pg. 112.

Due to this the equation changes for the bending moment once point B is passed. This causes the difficulty in evaluating the constants.

If one now makes use of the principle of superposition, namely, continue the downward load from B to the reaction C, then the bending moment equation remains the same. The only objection is the introduction of the additional downward load, and this objection is removed by introducing an equal and upward distributed load from B to C. Fig. 2 depicts this type of loading.

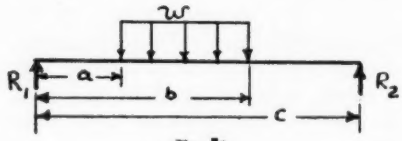

FIG. 1.

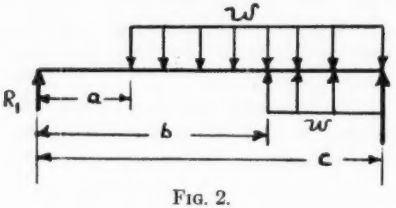

FIG. 2.

One sees that three equations are needed for each figure but let an inspection of the equations pertaining to Fig. 2 be made. The three equations are in the integrated form:

$$EIy = \frac{R_1x^3}{6} + c_1x + c_2 \quad [0 \leq x \leq a], \quad (1)$$

$$EIy = \frac{R_1x^3}{6} - \frac{w}{24}\{x - a\}^4 + c_3x + c_4 \quad [a \leq x \leq b], \quad (2)$$

$$EIy = \frac{R_1x^3}{6} - \frac{w}{24}\{x - a\}^4 + \frac{w}{24}\{x - b\}^4 + c_5x + c_6 \quad [b \leq x \leq c]. \quad (3)$$

Observe now that at the juncture points, i.e., $x = a$, $x = b$ Eq. (1) and (2) and Eq. (2) and (3), respectively, become identical except for the constants which are related by the relations:

$$c_1 - c_3 = 0 \quad (4); \qquad c_3 - c_4 = 0 \quad (5)$$

$$c_3 - c_7 = 0 \quad (6); \qquad c_6 - c_4 = 0 \quad (7)$$

or combining above

$$c_1 = c_5 \quad (8); \qquad c_2 = c_6. \quad (9)$$

Hence, Eq. (3) can be written in the form:

$$EIy = \frac{R_1x^3}{6} - \frac{w}{24}\{x - a\}^4 + \frac{w}{24}\{x - b\}^4 + c_1x + c_2. \quad (3a)$$

If one now agrees to omit the { } bracketed term when the quantity inside it is negative, it is apparent that Eq. (3a) reduces to Eq. (2) and Eq. (1) in the appropriate range of x. $c_2 = 0$ since at $x = 0$, $y = 0$. Hence, only *one* constant has to be evaluated to solve the problem.

Space considerations prevent a presentation of several types of problems but a short paper has been prepared by the author and will be furnished upon request. However, one can readily see that this method is a tremendous time-saving factor.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 15, 1952 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of Instructional Division Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Minutes of the Executive Board Meeting

A meeting of the Executive Board of The American Society for Engineering Education was held on Friday, January 11, 1952, at Northwestern University, Evanston, Illinois. Those present were: S. C. Hollister, *President,* M. M. Boring, A. B. Bronwell, W. L. Everitt (substituting for J. H. Lampe), L. E. Grinter, C. L. Skelley, W. P. Kimball (guest), and B. Bowen.

Participation of Younger Faculty Members in ASEE Activities

The Secretary suggested that consideration be given to methods of stimulating active participation of the younger faculty members in the meetings of the Society. Most of the officers of the Divisions, Committees, and Sections of the Society are faculty members in the upper professorial ranks. Younger faculty members are seldom elected to office or called upon to present papers at Society meetings. On the other hand, the younger faculty members have the most to gain by participation in Society affairs, since this would help them to improve their teaching, give them a broader perspective on all facets of engineering education, and expand their acquaintances and associations in the educational field.

The Executive Board recommended that the Sections consider developing conferences and activities which would be arranged and managed entirely by younger faculty members of instructor and assistant professor rank. It was also suggested that adequate publicity be given to these conferences in order to stimulate widespread attendance and participation by the younger faculty members.

The Executive Board recommended that a paper contest be inaugurated, with entries limited to young engineering teachers. The subject of the paper contest would be announced by the ASEE and prizes would be awarded for the best papers. In order to stimulate Section activities among younger faculty members, each Section would establish its own rules for the paper contest and judge its own entries. The winning papers of the various Sections would then be submitted to a national judging committee which would select the first and second papers. These papers would be presented at the Annual Meeting of the Society and the awards would be made at this meeting. It was recommended that the contest be held during the school year of 1952–53 and that the first awards be presented at the Annual Meeting in June 1953.

A motion was passed, recommending the establishment of two prizes of $200 and $100 to be awarded for the best two papers submitted by young engineering teachers on a subject to be announced by the President. The contest is to be developed by the Sections of the Society, with the winning entries submitted for judging by a national committee appointed by the President.

This matter will be referred to the General Council for consideration at its meeting in June.

Program of Cooperation with Secondary Schools and Junior Colleges

One of the major projects of the Society during the coming year will be the development of closer working relationships between engineering colleges, secondary schools and junior colleges. President Hollister re-emphasized the need for counteracting the steadily falling scholastic level of secondary school education, especially in the sciences and mathematics, and also the decline in interest of high

school students in engineering as a career. Dean Everitt presented the views of the ECAC, stating that the problem is basically one of stimulating activity at the "grassroots" level and that the program of cooperation must necessarily be developed by the individual engineering colleges. However he stated that the ECAC's Committee on Secondary Schools could serve in a very useful liaison capacity by making information available to the engineering deans as to the methods and accomplishments of various colleges in this field.

Committee on Evaluation of Engineering Education

The program of "Evaluation of Engineering Education" has been voted by the Executive Board as one of the major projects of the Society during the coming year. A national committee under the chairmanship of Dr. Grinter will be appointed to study this problem. In addition, the deans of engineering colleges will be invited to appoint committees from among their own faculty members to cooperate with the central committee in this study. The recommendations of the institutional committees and those of the national committee will be consolidated and correlated into a unified report. President Hollister proposed that the national committee meet at Cornell University to discuss the broader issues involved in engineering education prior to the Annual Meeting.

Universal Military Training

President Hollister stated that the Engineering Manpower Commission is formulating a policy recommendation to be presented in testimony before Congressional committees which are holding hearings on the UMT Bill. He stated that there was considerable prevalence of opinion in Washington that the UMT Bill would not be passed by Congress. The stand taken by the Engineering Manpower Commission is that if Universal Military Training is adopted, every physically fit male of draft age should be required to serve in the highest capacity depending upon his abilities and education. There will then be no question of deferment, but rather each draft age individual will be assigned to work either in the Armed Forces or in industry in the capacity where his education and skills are utilized to the best interests of the mobilization program.

EJC Committee on International Relations

Deans Lassalle and Steinberg have been appointed to serve as the ASEE representatives on the EJC Committee on International Relations. The EJC Committee has been working with agencies of the government in planning technical missions to European countries. Another technical mission on engineering education and research is contemplated.

UNESCO

Dean Everitt explained that the approach of the ASEE in seeking membership in UNESCO should be made to the chairman of the Membership Committee. The list of persons serving on the Membership Committee has been sent to Dean Lassalle in order that he may prepare material for a direct approach to the UNESCO Membership Committee.

Resolution of the Engineering Drawing Division

The Executive Board discussed the resolution of the Engineering Drawing Division, requesting that the ECPD visitation committees include qualified teachers of engineering drawing. It was pointed out that engineering accreditation has always been on the basis of curricula and not on the basis of subdivisional areas of curricula. The ASEE in the past has not made recommendations to include teachers of particular subjects on the ECPD accreditation committees. It was the consensus of opinion that it would be an unsound policy for the ASEE to make such recommendations, since it would open the door to similar requests in other subject areas.

Fall Meetings of the ECAC and ECRC

The Executive Board discussed the possibility of holding the Fall meetings of the ECAC, ECRC, and General Council at the time of the Centennial of Engineering in Chicago. This would serve to strengthen the attendance at the Centennial program by adding the support of the ASEE. It would also make it possible for a somewhat different group of deans of engineering colleges to attend the Fall meeting of the ASEE than those who usually attend the meeting when it is associated with the Land Grant College Asociation meetings.

The Executive Board voted to hold the Fall meetings in Chicago during the first week of the Centennial of Engineering, as close to the Symposium on Engineering Education as possible, the details to be worked out by the Secretary.

Location of Annual Meetings in 1954 and 1955

Dean Everitt repeated his invitation to the ASEE to hold its 1954 Annual Meeting at the University of Illinois. It was the consensus of opinion that this location would fit well with the ASEE geographical rotation plan and also that the facilities at the University of Illinois should be entirely adequate for the Annual Meeting.

The Executive Board voted to hold the 1954 Annual Meeting of the Society at the University of Illinois, the details of the meeting to be worked out between the Secretary of the Society and Dean Everitt.

President Hollister presented an invitation from Cornell University to hold the 1955 Annual Meeting at Cornell. The last meeting of the Society held at Cornell University was in 1934. President Hollister will prepare a letter of invitation to the Society. No action was taken on this proposal.

Plans for 1952 Annual Meeting

Dean Kimball outlined some of the plans for the next Annual Meeting at Dartmouth College, June 23–27, 1952.

Dean Kimball stated that the anticipated expenses for the Annual Meeting would be on the order of $4,300. This would require a registration fee of $4.00 per member, with no additional charge for other members of the family. A previous ruling of the Executive Board and General Council authorized the host institution to charge a registration fee not to exceed $4.00 per member. The Executive Board approved the registration fee recommended by Dean Kimball.

Dean Kimball extended an invitation from President Dickey to members of the General Council and their wives to be the guests of President and Mrs. Dickey at a dinner on Monday evening. The Secretary suggested that the newely elected members of the General Council, representing Sections of the Society, be invited to attend the Monday evening dinner, even though their term of office does not begin until ten days after the Annual Meeting. This would enable the new Council members to become oriented to the problems of the Society before taking office. The Executive Board approved this recommendation.

Dean Kimball stated that all members present and guests will be invited to a reception at the home of President Dickey from 4:00 to 6:00 P.M. on Tuesday afternoon.

Report on the Secretary's Office

The Secretary presented a report on the operations of the headquarters office. This report stated that the ASEE has operated with a small headquarters staff on a "decentralized" plan, whereby the Divisions, Sections, and Committees of the Society assume much of the responsibilities for their respective areas of operation. The headquarters staff concentrates its principal attention upon the major projects of the Society, although it also has the responsibility for coordinating the activities of the various Councils, Divisions, and Sections of the Society; editing the Journal; maintaining the membership records; arranging for the Annual Meeting; and handling the Society's finances.

This basic plan of operation has made it possible to carry on the Society's business with a part-time secretary and two office secretaries and with an annual dues structure of from $5.50 to $7.00 per member.

With the growth in size and operations of the ASEE, it has become necessary to add to the secretarial staff in order to relieve the Secretary of some of the routine responsibilities and free a portion of his time for developing liaison work between the ASEE and other organizations and government agencies. The report recommended the following:

(a) The employment of an assistant secretary on the basis of one day a week, at a salary of $800 for the six months period from the present time until July 1. The assistant secretary would review manuscripts submitted for publication in the Journal and in general supervise the editorial work of the JOURNAL OF ENGINEERING EDUCATION. It was recommended that Professor C. E. Watson, chairman of the Department of Industrial Relations at Northwestern University, be appointed to this post.

(b) An appropriation of approximately $780 be made for the purchase of two dictaphone machines for the office. These would substantially increase the volume of correspondence which can be handled by the office secretaries.

(c) It was recommended that an additional $200 be appropriated for stenographic assistance.

The Executive Board voted to approve the foregoing recommendations.

The report also presented a projected estimate of the income and expense of the Society for the next three fiscal years and included a summary of costs for several different plans of expansion of the Secretary's office.

Applications for Associate Institutional Memberships

The Executive Board voted to approve the following applications for Associate Institutional Membership.

Caterpillar Tractor Company
General Electric Company
International Minerals & Chemicals Corp.
International Nickel Company
International Textbook Company
John Wiley and Sons, Incorporated
Macmillan Company
McGraw-Hill Book Company, Incorporated
Reinhold Publishing Corporation
Scott Paper Company
Standard Oil Company (Indiana)
West Penn Power Company
Westinghouse Electric Corporation

Respectfully submitted,
ARTHUR B. BRONWELL,
Secretary

New Members

ANDERSON, ROY H., Assistant to Works Manager, Diehl Manufacturing Company, Somerville, N. J. A. A. Nims, F. A. Russell.

ATKINSON, RANDALL F., Assistant Professor of Architecture, Rensselaer Polytechnic Institute, Troy, N. Y. A. A. K. Booth, P. E. Hemke.

BEERS, ROLAND F., Professor of Geophysics, and Head, Department of Fuel Resources, Rensselaer Polytechnic Institute, Troy, N. Y. P. E. Hemke, A. A. K. Booth.

BERGESEN, ALF O. R., Special Student, Mechanical Engineering, University of Rochester, Rochester, N. Y. J. H. Belknap, A. B. Bronwell. (Reinstatement)

BLATHERWICK, ALLAN A., Instructor in Mathematics and Mechanics, University of Minnesota, Mineapolis, Minn. F. E. Miller, G. J. Schroepfer.

BURTON, ROBERT E., Manager, Control Division, Engineering Dept., E. I. du Pont de Nemours & Company, Wilmington, Del. T. H. Chilton, B. M. Taylor.

BUTLER, HAROLD T., Instructor in Management, Economics, History, Rensselaer Polytechnic Institute, Troy, N. Y. A. A. K. Booth, P. E. Hemke.

CAMPBELL, HENRY, Associate Professor of Civil Engineering, University of Rhode Island, Kingston, Rhode Island. T. S. Crawford, H. E. Graves.

CAMPBELL, ROBERT G., Assistant Professor of Aeronautical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. P. E. Hemke, A. A. K. Booth.

CLOUD, HAROLD A., Instructor in Agricultural Engineering, University of Minnesota, Minneapolis, Minn. A. Hustrulid, A. M. Flikke.

CRAINE, LLOYD B., Assistant Professor of Electrical Engineering, University of Idaho, Moscow, Idaho. P. Mann, J. H. Johnson.

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WISE, JOHN S., Research Fellow, Mechanics Dept., Rensselaer Polytechnic Institute, Troy, N. Y. A. A. K. Booth, P. E. Hemke.

ZIMMER, RUSSELL D., Instructor in Mechanical Engineering, Northeastern University, Boston, Mass. A. J. Ferretti, H. K. Brown.

339 new members this year

(*Continued from page 353*)

Those who missed the extremely interesting trip to the Columbia University Cyclotron in order to make the equally enjoyable inspection of Pavelle Color Laboratories, were not without an insight into the field of atomic behavior. Dean Dunning's brilliant talk at the annual dinner on the strides being made in the practical application of Atomic Energy was explosive in its revelations and his unique demonstrations were entertaining in the extreme. His talk created a profound interest in the unlimited possibilities of this relatively new science.

Your Executive Committee met on Wednesday evening to discuss the report of the Policy Committee, and to approve the program for the next annual meeting at Dartmouth. The Policy Committee, consisting of Professors Higbee, Hoelscher, and Justus Rising, submitted a specific policy for the selection of men to be given the Division's Distinguished Service Award, and this policy was approved by the Executive Committee. It will be published in a future issue of the *Journal of Engineering Drawing*. With respect to the trend toward reduction of time devoted to drawing in engineering curricula, the Policy Committtee reported that it has initiated definite action for corrective measures, and recommended a continuing policy. Pending further developments this report was accepted by the Executive Committee.

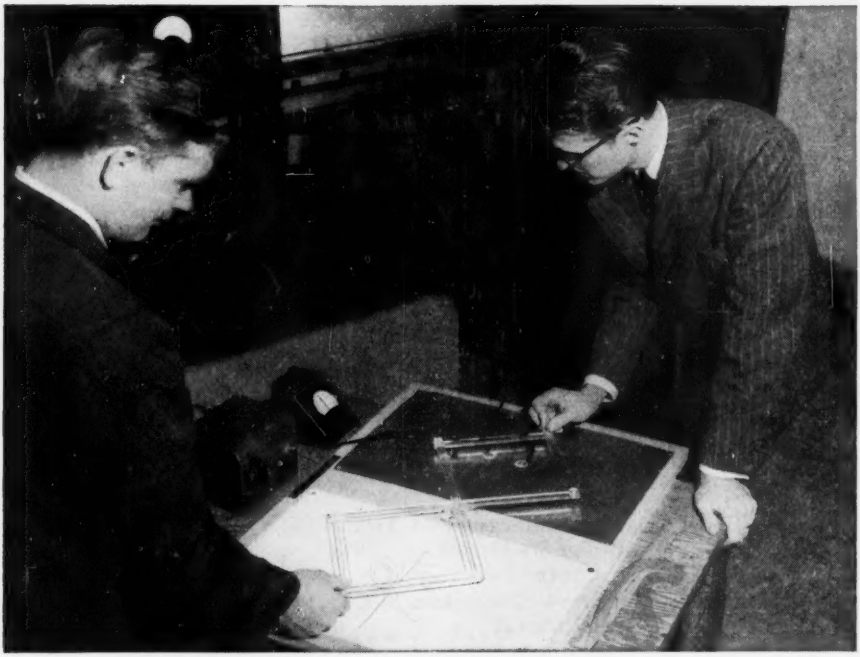
The topics selected for the June meeting cover a broad range of interests, and the list of speakers is headed by Dean S. C. Hollister, President of the Society. Better make plans now for that trip to Dartmouth. Everyone else will be there—why not you?

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State College	April 18–19, 1952	E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Newark College of Engineering	December, 1951	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oncken, Jr., Bureau of Ordnance
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Washington	April 25–26, 1952	T. H. Campbell, University of Washington
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	S. F. Duncan, University of Southern California
Rocky Mountain	University of Wyoming	April 19, 1952	E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 11 & 12, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.



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Thayer School of Engineering

Annual Meeting of the ASEE
June 23–27, 1952

The Thayer School of Engineering, an Associated School of Dartmouth College, holds in the minds of those who know it many distinctions in the field of engineering education. Of these distinctions, two at least cannot be controverted: it shares with no one the distinction of having originated and for over eighty years adhered continuously and exclusively to the "five-year curriculum"; and it has long maintained, and by firm intention and with clear purpose will continue to maintain, one of the smallest enrollments of engineering students in the country.

The Thayer School offers complete curricula in civil engineering, electrical engineering, and mechanical engineering accredited by the Engineers Council for Professional Development. A fourth curriculum, in engineering and business administration, is offered by the Thayer School in conjunction with Dartmouth's Amos Tuck School of Business Administration.

The objective of the engineering curricula is to educate men for professional careers of public responsibility as well as for technological activities. Through its close association with Dartmouth's liberal arts program, the School is in a position to render a unique service in the field of engineering education. The professional engineer of today has both an obligation and opportunity to direct his technological endeavors toward the service of society. In order to do so he must have an understanding and appreciation of the needs and problems of the world in which he lives, which cannot be acquired in a course of study limited to scientific and technical subjects. The engineering student at Dartmouth follows a pre-engineering course for three years in the liberal arts college before entering the professional school. During these three years, he acquires a background of both general education and science courses in the atmosphere of a liberal arts college and in association with liberal arts students. This association is continued through his first year in Thayer School in the Great Issues course which is required of all Dartmouth seniors. Building on this foundation of education in the humanities and the social and natural sciences, the engineering studies offered by the Thayer School prepare men for the broadest possible usefulness both within the engineering profession and in community life.

Between thirty and forty students are normally admitted each year, and the enrollment in each of the four curricula offered by the school will therefore average less than ten students per year. Classroom sections are limited to twenty students and seldom exceed fifteen. Laboratory sections are generally held to ten students. This limited enrollment makes it possible to provide intensive instruction under close personal supervision and to realize fully the benefits to be derived from close contact between student and instructor.

Centennial of Engineering

In welcoming representatives of engineering schools throughout the country to the 1952 Annual Meeting of ASEE, Dart-

mouth observes the centennial of engineering instruction on her campus. Just one hundred years ago, civil engineering courses were initiated as part of the program of the Chandler Scientific School established at Dartmouth in 1852 by gift of Abiel Chandler. After the establishment of the Thayer School in 1871, the Chandler Scientific School became a department of the College and it has subsequently been absorbed by the Science Division, but civil engineering instruction has been continued on the Dartmouth campus without interruption for one hundred years. It is an interesting coincidence that 1952 also marks the hundredth anniversary of the founding of the American Society of Civil Engineers and is being observed throughout the country as the centennial of engineering in the United States.

The Thayer School was established by the gifts of General Sylvanus Thayer whose underlying thought was that the preparation for an engineering curriculum must be a liberal arts college course which should entirely precede the work in the professional school. Sylvanus Thayer was graduated from Dartmouth in 1807 and from the United States Military Academy in 1808 with highest rank in his class in both institutions. At the age of 32 he was appointed Superintendent and assigned the task of reorganizing the Military Academy. One of his biographers has said of him, "Major Thayer's military experience, his foreign travel and associations, his familiarity with the polite usages of society, his dignified bearing and refined mode of life, and, above all, his scientific acquirements, enlarged professional reading and familiarity with the French and dead languages, gave him immense vantage ground for success." Between 1817 and 1833 he made the United States Military Academy one of the most famous and effective military schools in the world. In recognition of his work the Academy has erected a monument on its campus, and he is generally regarded as "the father of the Academy." He spent the closing years of his life planning an engineering curriculum based on the experiences of his own career. This work culminated in the founding of the Thayer School in 1871, just one year before his death.

Preparation for Professional Careers

Although Thayer School graduates are prepared and qualified to continue their formal education in specialized graduate work leading to more advanced degrees, and some have done so with signal success, the school's primary objective remains, as conceived by its founder, to prepare its graduates for professional engineering careers. Both the arrangement of the

programs and the instructional methods are aimed at the accomplishment of this objective by placing the emphasis on breadth and the study of fundamentals and avoiding narrow specialization.

The pre-engineering courses required during the first three college years are the same for all curricula and about two-thirds of the work of the fourth year consists of engineering fundamentals common to all curricula. Through individual counseling by members of the Thayer School faculty, students are advised to choose electives during the first three years from the offerings of the social science and humanities divisions in order to take fullest advantage of the opportunity to broaden their educational experience. An incidental but important feature of this arrangement is that the student may postpone his final choice of engineering field until the beginning of senior year when he is far better qualified to choose his field of study than during freshman or sophomore year. It is also possible for the student to transfer without stigma or penalty from engineering to another area of study at any time during his first three years if it appears that his interests or aptitudes lie outside the field of engineering.

In the fourth and fifth year courses in specifically civil, electrical, or mechanical engineering subjects the theoretical and practical fundamentals are stressed. Except for the individual or small-group projects in the fifth-year curricula, all courses are required for all students enrolled in each of the three programs offered.

Instructional Methods

Instructional methods are designed first to instill in the student the habits and procedures of engineering analysis and workmanship and, having accomplished this, to provide him with maximum opportunity to develop judgment, initiative and self-reliance in the performance of assigned tasks and projects. In classroom, design and laboratory periods, every attempt is made to keep the student participation factor as close to 100% as possible. Student maturity and small enrollment are felt to be vital factors in making these instructional procedures possible and fully effective.

Thayer School is particularly fortunate in its physical plant. After "making do" in traditional New England fashion in a series of buildings converted from their original use for other departments, the school moved into the Horace S. Cummings Memorial in 1939. This building was expressly designed and newly con-

structed to meet the needs of the civil engineering program offered by the school at that time. Immediately after World War II, two wings were added to house the new electrical and mechanical engineering programs. This complete unit stands at the west end of Tuck Mall just opposite the Tuck School of Business Administration and three hundred yards west of Dartmouth's central building, the Baker Library. It will be open for inspection throughout the week of the Annual Meeting and ASEE members and guests are cordially invited to visit the building and view the laboratories, engineering library, and other facilities at any time.

The Third National Surveying Teacher's Conference

Sponsored by

Committee 8, Civil Engineering Division, ASEE

and

The University of Illinois

August 3–8, 1952

Camp Rabideau, Summer Surveying Camp of the University of Illinois, will be the scene of The Third National Surveying Teacher's Conference, August 3–8, 1952. Situated in the Chippewa National Forest of Northern Minnesota and in an area famous for its lakes and Paul Bunyan lore, Camp Rabideau with an unparalleled physical plant and pleasant woodland environment offers excellent facilities for conference activities and communal living.

The Illinois Surveying Camp is located on federally-owned forest land in Beltrami County about 35 miles northeast of Bemidji. Deer and small game abound in the heavy stand of second-growth timber that covers this region. Daily rail and bus service is available from Minneapolis to the village of Blackduck which is 6 miles north of the camp. Good highways approach the area from all directions.

For further information address Brother B. Austin Barry, F. S. C., Chairman Committee 8, Civil Engineering Division, ASEE, Manhattan College, New York 71, N. Y.

Dining and sleeping accommodations will be furnished at a cost of about $25 per person for the six-day period. A reduced rate will be made for children. Reservations should be made with Dr. M. O. Schmidt, Director of Camp Rabideau, Surveying Building, University of Illinois, Urbana, Illinois.

Higher Education and the Problems of This Decade[1]

By J. HILLIS MILLER
President, University of Florida

Any problematical approach to the decade of the 1950's involves a great deal more than higher education. However, that higher education is an important factor in the solution of these problems is an assumption which we make at the very beginning. Since this paper is to deal almost exclusively with higher education, it follows obviously that the discussion as a whole will be incomplete and inconclusive. Moreover, any brief statement of this kind will not include even a listing of all the problems of this decade, and, because of the limitations of time, the discussion will not exhaustively nor adequately set forth, even from an educational point of view, those problems that are brought within the focus of attention.

We shall not discuss the traditional functions of higher education such as its function of teaching citizens to think, to search for truth, and to make decisions in terms of the best information and knowledge that is available to them. We shall not discuss professionalism in higher education, nor types of higher educational institutions. We shall not attempt to define higher education, and thus run the risk of detracting from the pastime of many educators who spend their energies dealing with invidious comparisons as to the specific theories of higher education. We shall not dwell upon the inertia of higher education, nor its failure to train the wills and intellects of men and women for whatever functions they may be called upon to serve. In fact, we shall not discuss higher education from the point of view of higher education at all, but rather from the point of view of society. Higher education, for the sake of this discussion, becomes an instrument for meeting some of the problems of our society. Therefore, its own problems are disregarded to a very considerable extent in order that attention may be focused upon society itself. Indeed, such an approach is good for higher education since in losing its life in service to the world it may well find it again.

Assumptions

Having in this fashion cut through the mangroves that surround any discussion of higher education, we are in position to make certain positive assumptions as we discuss the new role that higher education should play in connection with some of the pressing problems of the society of which we are a part.

First of all, we assume that higher education has a mental hygiene of its own. To state it another way, we assume that higher education possesses a vigor and healthy-mindedness that will enable it to make its contribution to the solution of the pressing problems which are present today and which will unquestionably persist in the decade of the 1950's. If higher

[1] A speech given at the Commodore Hotel, New York City, September 27 and 28, 1951, sponsored by the American Council on Education. Originally appeared in *The Educational Record*, Oct., 1951, and published here by consent of the author and the American Council on Education.

education is to lead the way, it must dismiss the sense of futility which pervades the thinking of so many men and women today. For example, many good church members despair of being able to halt the trend toward secularism, and many good democrats (in the generic sense of the word) seem to feel that we have to forsake democratic procedures in order to defend democracy.

There are a number of additional assumptions which should be listed if the new role for higher education is to be understood. It must assume that we can profit from the mistakes of the past as well as the successes of the past. It must assume that the rights of the ordinary man are to be protected. It must assume that the mind and will of man are more powerful than all other forces in the world. It must assume that unmitigated speed is not as effective as the slow and tedious process of human thought. It must assume that science is a neutral factor and that it can be used for the upbuilding of civilization. It must assume that man's organizational ability to get things done can be turned in the direction of the orderly development of man's life on earth rather than that it must be used for the destruction of our world. It must assume that inevitable change can be turned in the direction of service to mankind rather than in the direction of man's ultimate destruction. And it must assume that permanent peace is obtainable. All of these assumptions, and more, must be made if higher education is to make its contribution to mankind during the next decade.

Unorthodox Approach

The approach we are making to the function of higher education and its contribution to the solution of the problems of the next decade is an unorthodox approach. Higher education cannot go its own way, and in its old ways, if it is to meet the needs of the time. It must carry on many of its old functions: it must continue to admit students to classes and curriculums and it must graduate them from colleges and schools and send them out into the world. We are not suggesting that higher education should subtract from its present activities so much as that it must add to them. It should not digress from its traditional pattern of service so much as it should aggress into areas that need its attention. We suspect that many of the new functions of higher education, which we shall suggest, are in areas which are now covered by the activities of higher education. More intensified tilling of the soil and more aggressive action in many of these areas are in order.

With these limitations and assumptions in mind, we may attempt to underline the areas of tension and danger in our society to which higher education must effectively and aggressively give its attention.

It is the function of higher education to redefine a desirable civilization. This problem is outlined in some detail by William H. Kilpatrick in the May 1951 issue of *Educational Theory*. There are many points at which we would differ with Kilpatrick's position, particularly with his concept of individualism. However, his definition of a desirable civilization is challenging: "Freedom, freedom to be one's self, freedom to work out one's own position in the group as opposed to the hereditary caste system of feudalism; equality, equality of treatment before the law, equality with others affected to decide what the law shall be and who shall govern, as opposed to arbitrary government by hereditary rulers, 'equal rights for all, special privileges for none'; freedom of thought, freedom to think, to speak, to argue, to persuade, to publish as each might wish as opposed to dictation and repression along all these lines; specifically, freedom of religion, freedom to believe or not to believe and to say so, as one's own study and conscience shall decide with legal freedom to support any religion or none as each may choose."

Kilpatrick goes on to say that these things mean democracy with its active respect for personality wherever found. It is the responsibility of higher education in this country during the next decade to show

the conflict between this kind of definition of a desirable civilization and the conflicting definitions of "civilizations" which have resulted in the social tensions of our world. These tensions are not clearly defined, and, consequently, our concept of a desirable civilization is not clear. It may be that the American view of a desirable civilization is best understood as a radical departure from the traditional European patterns. Moreover, the term "Oriental" covers so many diverse and fundamentally different cultural patterns that we find difficulty in deciding what we contrast with American democracy. Likewise, the secular, parliamentary government of India is not Oriental, and if it is not American or European it certainly is much more like them than like the earlier Oriental despotisms. The chances are that these difficulties can be circumvented by reference to the several ancient cultural patterns of Asia now emerging from colonial domination and seeking ways through the morass of poverty and ignorance toward something different. The tensions arising over the conflict between Russian communism and democracy are more clearly defined. Even here the conflicts are emotionally charged and leave much to be desired from the point of view of intellectual clarity.

Higher education must face the fact that the mass hysteria of our times makes it almost impossible for anyone to think honestly or to speak frankly on these issues for fear of being branded radical or subversive. As President Truman pointed out in Detroit on June 28, 1951, this fear has reached extreme proportions. On that occasion he said, "On the fourth of July over in Madison, Wisconsin, people were afraid to say that they believed in the Declaration of Independence. A hundred and twelve people were asked to sign a petition that contained nothing except quotations from the Declaration of Independence and the Bill of Rights. One hundred and eleven of those people refused to sign that paper—many of them because they were afraid it was some kind of subversive document and that they would lose their jobs or be called communists." We confess a certain suspicion concerning this incident, but the kind of thing suggested here makes the battle against communism a confused one, with the result that too many people on all levels are simply taking on a kind of protective silence on the theory that what they do not say cannot hurt them. This leaves the real concept of democracy singularly defenseless among the very people who should be its leading exponents. Higher education must do more than "face the fact"; it must, by its very nature, provide an antidote to fear and hysteria. Its weapons are scholarship and enlightenment.

Higher Education Must Inspire Statesmanship

Higher education must redefine the functions of politics and government in a democratic civilization. The field of political science, as it applies to the history of social organization and to the government of the people must undergo a thoroughgoing review by higher education, in order that we may bring to an end the trend toward bad government and establish once again true government of and for the people. There is a very general trend today for politics to destroy good government as well as good education. To state the matter in more positive terms, it is a function of higher education to define not only good government but good statesmanship as a means of developing and maintaining good government. Higher education must not be content to teach political science; it must develop and promulgate a science of government that inspires statesmanship and not political expediency.

Higher education must not only define civilization and the role of government and politics in maintaining civilization, but it must redefine the practical objectives of a good civilization to which government and education may address themselves. We are here combining the forces of education and government. For too long education has attempted to separate itself

from government, but in view of the kind of world we have developed, this would seem to be no longer a desirable dichotomy. To unite the forces of government and education would strengthen both government and education. It would then be the function of education to define the objectives of a good civilization and the function of government and education in achieving these objectives.

The practical objectives of a good civilization fall naturally into three categories as follows: (*a*) those having to do with international relations; (*b*) those having to do with internal relations in a democratic society and with community relations within such a society; and (*c*) those having to do with human nature and human personality as they impregnate the whole. Among the practical objectives of a good civilization having to do with international relations, the following are prominent: to maintain international peace and good will; to share industrial advantages and scientific achievements with other nations less favored than ourselves; to develop greater international understanding; to show how nations might live in one world without war, or in two worlds if Willkie's "One World" is not obtainable; to prevent the depletion of the world's natural resources and to restore the "plundered planet"; to focus world attention on results that must follow from present national and international policies; to demilitarize the world; and to perfect some kind of a federation of authorities for the purpose of developing a plan and procedure for uniting the cultures of the world.

Among the practical objectives of a good civilization having to do with internal and community relations, the following may well be considered: to develop and to perpetuate the freedoms of democracy; to promote economic well-being; to help education to help itself; to maintain freedom from pressure groups, including political interference; to defend democracy and private initiative from the encroachment of communism; to learn how to use our expanding industrial economy without destroying individual rights and privileges and without becoming regimented and state dominated; to continue the expansion of our national income and its use for the accomplishment of higher standards of living, the further advancement of culture, and other values; to accept the facts of history for what they are worth as examples of past success or failure; to show how atomic energy and other contributions of science may be used for improving the way of life for the mass of mankind; to show how we may further advance our knowledge of science in order that we may increase our chance of survival if attacked; to encourage the development of public character as a bulwark against its further disintegration; to strike a judicious balance between change and the *status quo;* to teach men to take the long view rather than to be everlastingly absorbed by the things of the moment; to give to educational institutions the effective means of education now used largely for commercial profits such as movies, radio, television, and newspapers; to substitute reliable information and reason for emotional appeal as a basis for popular opinion and popular allegiance; to promote "cultural pluralism" as one aspect of a wholesome culture and to affirm it against totalitarianism and cultural fragmentation; to promote democracy through education; and to give our people a world view.

Practical Objectives

Among the practical objectives of a good civilization having to do with human nature and human personality, the following may be included: to develop human nature through education; to develop a positive and creative leadership; to help people adjust themselves to a rapidly changing world; to dispel hazy thinking; to develop the concept of unselfishness; to denounce mediocrity; to discourage lachrymose pessimism; to encourage assumption of responsibility to teach recognition and analysis of problems; to discourage men and women from being obsessed with the obvious; to discourage men and women

from believing absurdities; to develop social outlook and personal insight; to show how individuals may find a satisfying life without doing injury to others; and to prevent a sense of futility and a feeling that we are at the mercy of forces beyond our control.

The foregoing are a few of the desirable practices of a good civilization which should be clearly defined and set before the world by the forces of education as practical objectives of a good society. It will be possible in this brief discussion to enlarge upon only a few of these areas of human endeavor for illustrative purposes.

It is the function of higher education to invade more effectively the field of international relations; to address itself as vigorously to the problems of the world as they bear upon the relationship of nations, as the nations of the world are pursuing through noneducational means their own nationalistic tendencies and their own vested interests. Thus far in the development of world civilization, international relations have not brought peace upon the earth. The best minds of the country must address themselves to the problems of effective relationships between nations in order to give some promise of security to the human race. The American Council's publication *The Role of Colleges and Universities in International Understanding* is a remarkably comprehensive and detailed statement of the many opportunities and responsibilities of colleges and universities in this field.

This field of endeavor may be illustrated by reference to our loss of the friendship of Asia and our need for restoring that friendship. In the past the people of Asia, especially the Chinese, have, on the whole, trusted and admired the people of the United States. It is therefore painful to witness the turning away of our Chinese friends, the distrust of India, and the outright hatred of the North Koreans. As most of the people of the world live in Asia, it will be impossible for America as we know it to survive if Russia wins the contest between communism and democracy. If the Korean War can be brought under control, the United States should use every means within its powers to allay the fears of what Asiatics call American imperialism and to remove the causes of frustration. Asia considers that it has had bad treatment from what it refers to as imperialistic nations, with whom we are associated in the eyes of every Asiatic. The average American finds imperialism distasteful and our government and our education should more clearly express the feelings of the average American on this point than they do at the present time.

The frustration of the people of Asia is an urgent problem. These people are frustrated because they are desperately poor, because the white man has made them feel inferior. This point of view was brought out in the third yearbook of the Society for the Psychological Study of Social Issues in 1945 at the close of World War II. The report predicted fairly accurately what is now happening in Asia. It said in so many curiously combined words that the hazards that face us in the coming decades will not be hazards resulting from the frustrated peoples of the world, but from the frustrated peoples of the world being surrounded by populations with psychologically rich traditions as regards war, and with none of the groups possessing a unified and clear machinery for the maintenance of peace.

Perhaps the answer to this problem is that we should listen more carefully to our social scientists and less to the politicians of the world. Reflection upon our own history in relation to Europe should furnish a perspective in which we could appreciate better the sensibilities of those emerging from colonial domination. We need to make an unprecedented and heretofore undreamed-of effort to dissociate ourselves from the policies and practices discredited by history. It is the role of higher education to discover and to seek to implement these new ways in dealings between ourselves and the peoples of Asia.

Human Equation

Since some of the practical objectives of a good civilization are to be found in areas now served in a traditional way by higher education, a few references to some of these areas might be helpful in defining the new role of higher education in the new world. For example, higher education must review the function of science and engineering and their relationship to the human family. The true functions of science and engineering, apart from their functions of gaining knowledge and understanding, is to make the world a happier place in which to live, a better place in which to live, and a more convenient place in which to live. They must relate themselves more closely to the human equation and consider their effect upon the minds and souls of men.

An entirely different type of objective for higher education is suggested by the word "vocation." Higher education has always been concerned with the vocations that men and women follow. It is desirable in these times to call upon education to review the whole problem of the role of man in carrying on the work of the world as related to his role as a social being. Vocationally minded men and women have departed from the Emersonian theory of man to the effect that when man was created he was not only divided into men that he might carry on the work of the world, but that it was his responsibility upon returning from his job of doing the world's work to give his attention to the problems of serving his fellowmen. One's vocation can no longer be considered as an end in itself, but as a means of contributing to the welfare of mankind. The great professions and the professional schools have social obligations that are as compelling as those implied in the objectives of general education.

It follows that if higher education is to review the areas of life commonly reserved to politics and government, international relations, science and engineering, and vocations, it must give its attention to the whole problem of the social sciences and the needs of the common man. Higher education must raise the question of the ends to be served in politics and government, international relations, science and engineering, and vocations. Ordinary courses in sociology are not sufficient. Higher education must address itself to analyzing the needs of mankind that are to be served by the activities of leaders in all walks of life.

Just as surely as we raise the question of the social sciences and their relationship to other services performed by the leaders of our society, we raise the fundamental question of the moral, ethical, and spiritual disintegration of our society. We seem to have lost our sense of values. We find the disintegration of personal character in every phase of modern life. A simple course in ethics in our colleges and universities will not do the job. The problem must be approached on a broad front by all of the forces of higher education in this country.

The crisis in character deserves further analysis. There seems to be little doubt that the greatest problem facing education and the world today is ethical or moral in character rather than intellectual or political. We have made such rapid strides in scientific studies and intellectual pursuits that we have not only got rid of most of our superstitions but we may be on our way to losing a great deal of our faith. In this connection, Arnold Toynbee has been an outstanding spokesman. This historian believes that nations and cultures thrive and advance in direct proportion to the degree of loyalty they maintain to spiritual principles. He also believes that ours is a tottering civilization which "has shamefully succumbed to the intoxication of a showy victory over physical nature, and has applied the spoils to laying up treasures for itself without being rich towards God." Professor Ralph Gabriel, after an objective study of American democratic thought since 1815, says: "The basic postulate of the democratic faith affirmed that God, the Creator of man, has also created a moral law for his government and has endowed him with a

conscience with which to apprehend it. Underneath and supporting human society, as the basic rock supports the hills, is a moral order which is the abiding place of the eternal principles of truth and righteousness."

The recent national scandals of various sorts have focused attention sharply upon our failure inhigher education to inculcate moral and spiritual principles. The pragmatic policy of decrying all absolute values in looking upon right or wrong simply in the context of what works in a given situation is under sharp attack. If our American education is grounded upon such foundations, it and our civilization are "dead ducks," as Toynbee has so aptly said.

Character is Learned

Higher education must recognize the fact that character is learned and the learner acquires special characteristics from his experiences. If it is true that character is learned, and if it is true, as seems unfortunately to be the case, that there is a disintegration of personal integrity in our society, then it follows that the remedy lies, to some extent at least, in the field of education. In this connection, we do not believe that character can be based upon human personality alone as Walter Stace, at the Mid-Century Convocation on the Social Implications of Scientific Progress, held at the Massachusetts Institute of Technology, seemed to contend. He said in a panel discussing science and faith: "My thesis is that morals were formerly believed to be based on supernatural or metaphysical foundations. This belief is disappearing so that morals seem to have no foundation. This has produced a crisis in the human spirit, also of moral faith. But this is all based on a mistake. Morals have a perfectly firm and objective foundation in human personality. If man can be brought to understand this, then moral faith may be restored. The problem is really one of education." We do not believe that education has to ignore the traditional religious basis for character development.

Higher education cannot invade the area of value-judgments and undertake to restore the integrity of mankind without undertaking to analyze and solve the whole problem of criminology. The legal approach to the solution of the problem of crime has failed. All our courts of justice, all our penal institutions, and all our education have not halted the disposition of a large segment of our population to engage in criminal acts of every conceivable kind. Again, a course in criminology is not the solution. There must be a concerted effort on the part of higher education to deal with this problem in an intelligent and constructive way.

Higher education must invade the realm of religion, and strengthen religion in its efforts to make the world a better place in which to live. A transmission of our great spiritual heritage has not taken place. Generation after generation of school children and those in higher education are receiving only the most cursory treatment of the whole subject of moral, ethical, and spiritual values. Our failure to transmit the spiritual heritage of our people is due in large measure to the confusion which we have experienced as regards the meaning of the separation of church and state in our schools. We have interpreted this to mean the separation of school and religion, and the result of this has been that a teacher, at state expense, can espouse the cause of any philosopher or theorist, can indeed attack organized religion, but he cannot in the line of duty openly support a religion, or religious ideas especially, without subjecting himself to censure and without making the school subject to legal action to stop the teacher from so expressing himself. This confusion has in part contributed to the moral and ethical illiteracy of our generation, as evidenced by what takes place in government, business, and the professions beginning at Washington and extending to the outermost parts of the land.

Higher education must also give greater attention to the arts and to the finer expressions of the human mind and the human soul. The mind of man must be

conditioned to love the finer things of life. This can come about only as our leaders, who are conditioned in our institutions, have the proper appreciation and love for the artistic and aesthetic expressions of man.

As we invite colleges and universities to invade the whole realm of moral, ethical, and spiritual values, the wars which we have fought and which we are fighting today take on a different meaning, and it is not an insignificant observation that colleges and universities have been at war ever since the beginning of the Second World War. They are still training our officer personnel and working in their laboratories on the most destructive weapons to wage war ever conceived by man. These activities seem to be necessary, but one of the great problems of the next decade is how we can save the soul of higher education while thus engaged.

Mental Health

As we have observed, many of the practical objectives of a good civilization have to do with human nature and human personality. Moreover, many of them have to do with the attitudes of men and women and the poise and tranquillity by which they deal with the crises of our modern civilization. Therefore, we believe that higher education must invade the whole field of mental health and help the people of our country and world to obtain an orientation to the difficult times in which we live. The needs of mankind in this realm are demonstrated by the tremendous sale of books, written in many cases by relatively incompetent people, which hold some promise of giving mankind the peace of mind that it seeks. The minds and souls of men are weary, uneasy, and frightened; and they seek comfort and tranquillity. If higher education is to make its contribution to the solution of these problems, it must release itself from its moorings, extend its field of effort and make its contribution to the solution of the problems of the human mind. Again we contend that courses of study alone will not solve these problems. It will take the concerted efforts of the best minds of our day and generation. Not all of these minds, but many of them, are to be found in the field of higher education. This great human potentiality must be unleashed and directed toward the solution of our common problems.

In this brief paper on the problems of the next decade and the functions of higher education in helping to solve those problems, we have dealt with higher education in a thoroughly unorthodox way. In our opening paragraphs we attempted to set the stage for such a discussion by placing certain limitations on our analysis of the problems and the possible solutions to them. We dismissed the orthodox and traditional functions of higher education in order that we might give serious attention to the new role of higher education in the years that lie immediately ahead. In dealing with this new role of higher education, we assumed for it a vigor and healthy-mindedness that seems to be necessary if it is to perform its true function in the decade of the 1950's.

We ventured to assert that the primary function of higher education in the next decade is to redefine what we mean by a desirable civilization, and to defend that civilization intelligently against the encroachment of other so-called civilizations which have resulted in the social tensions of the world. We advanced the conviction that it is not only the role of higher education to define and defend a good civilization but to define the practical objectives of such a civilization in order that all the forces of democracy might combine in an effort to accomplish these objectives. Our justification for calling upon higher education to render these services is that the times in which we live are unusual times. Dangers lie all around us. The disintegration and even the destruction of mankind are not an impossibility. Whether or not we save our world may well depend upon many things but certainly the contributions of higher education during the next decade will be significant.

How higher education is to perform its significant role is a difficult question to answer. When one realizes the modest intellectual and scholarly equipment which most young people bring to college and how much time all of us, teachers and students, have to devote to keeping abreast of current responsibilities, we realize how little time and effort we can devote to looking ahead. Are we, therefore, merely engaging in a kind of wishfulness? We think not. There is still, we believe, an unused increment in our colleges involving individual teachers, research scholars, and students, that can be marshaled for some of the responsibilities we have outlined.

Our Task

First, we can set ourselves the task of understanding the problems of the next decade. Such an understanding would make the entire educational process more meaningful. Moreover, we can join hands with teachers, research scholars, and students throughout the world in a concerted effort to develop ways and means of solving our common problems. Finally, we can come out of our ivory towers and join hands with government and men of affairs to the end that all of the forces of democracy may be unified in the common task of creating and defending what we have referred to throughout these pages as a desirable civilization.

College Industry Conference

About 500 representatives from New England colleges and industry attended the fourth College-Industry Conference, sponsored by the Relations with Industry Division of the American Society for Engineering Education, at the Massachusetts Institute of Technology.

The conference theme was "The Engineer as an Individual." Opening addresses were given by Dr. Karl T. Compton, Chairman of the Corporation of M.I.T., and Dean S. C. Hollister of Cornell University, who is President of the American Society for Engineering Education.

Principal addresses of the morning session were given by Morris Meister, who discussed the secondary school aspects of the engineer's training; Jess H. Davis, President of Stevens Institute of Technology, who discussed the college aspects of the engineer's training; and H. N. Muller, who discussed the engineer's industrial training in his first year out of college.

The afternoon session of the conference was devoted to three simultaneous panel discussions centered on the themes of the morning talks. Moderators for the panel groups were K. B. McEachron, Jr., Ralph A. Galbraith, and J. C. McKeon.

Development and Utilization of Engineering Talent*

By J. C. McKEON

Manager, University Relations, Westinghouse Electric Corporation

Training and proper utilization of the limited supply of scientific and engineering personnel is the most critical problem facing our nation. The defense of our way of life and the re-establishment of any semblance of peace demand that we, as a nation, become strong economically and militarily—and remain strong. We must maintain a commanding lead in pure scientific research, engineering developments, and industrial production. Such a tremendous undertaking requires trained personnel. The cold fact is we do not and will not, in the foreseeable future, have enough technically-trained men to meet industry and military needs.

Utilization of Technical Manpower

Members of ASEE are fully aware of the engineering manpower crisis. President Hollister's studies urge the establishment of sound policies to allocate available technical manpower to industry and the military, to utilize talent effectively, as well as to encourage qualified high school students to enter engineering. The members are also familiar with the steps being taken by this Society, E.J.C., and other professional groups to bring the need for action to the attention of policy makers in industry, government, and the general public. The progress of these organizations is well-known to each of you.

The manpower crisis challenges each of us as individuals. For in the last analysis, this problem must be solved by the management of each company. True, the solution, in part, lies in the establishment of sound national policies. However, while organized groups are working at the national level, we must make sure we are doing everything possible to meet the situation in our own organizations. In the critical days which lie ahead, greater emphasis must be placed on the responsibilities of the individual units employing engineers.

Although there are many aspects of the manpower problem, I shall confine my discussion to the development and effective utilization of technically-trained men within a company. The first step toward a constructive personnel development policy is the realization that your company will be unable to secure all the technical manpower required, either through the recruitment of young engineers and scientists from the colleges, or by the employment of experienced men from other companies. Although management recognizes the problem, generally, the tendency is to think in terms of the shortage affecting the other company and that somehow your company will get all the technically-trained men it needs. Facts do not justify such optimism.

The second step is acquiring an appreciation of the value of a personnel development program. Productivity per engineer can be increased through effective training and personnel development.

* Presented at the Winter Meeting of the American Society for Engineering Education, Middle Atlantic Section, Newark College of Engineering, December 1, 1951.

The experience of enlightened organizations has demonstrated the value of well-planned programs. Proper job placement, higher level of technical competence, better supervision, greater job satisfaction spell higher productivity.

Moreover, an effective development plan gives assurance that the individual skills will be used to the best advantage. A properly managed program aims, not only to find and develop talent, but to use the native and acquired skills. This objective is accomplished by employing the young engineer's present abilities at the highest possible level and, at the same time, develop his technical and social skills for positions of enlarged responsibility. To meet the impending crisis, the top management of every industrial organization must vigorously support an integrated personnel development program. In some companies it means the inauguration of a new plan; in others, the realignment of existing programs and filling-in the gaps is all that is required. Few companies, if any, can rest on their laurels and remain in business during the next quarter century.

Having recognized the manpower problem and being convinced of the value of personnel development, we are ready to translate our ideas into a program of positive action. This brings up the question—what type of program should be established? The answer depends upon the nature of the company. The type of goods produced or services rendered, channels through which goods or services are marketed, geographical location, labor conditions, past experience with training programs, calibre of present supervision, and management philosophy are factors to be considered. In most organizations, it is advisable to introduce the program in steps, particularly in companies in which the first line supervision is not training-conscious. The transition in such organizations should be gradual.

Irrespective of the foregoing variables, there are a number of training and educational areas a program should embrace. For a picture of what I have in mind, I will highlight the essential features of a program for professional people which has proved successful in the organization with which I am associated. Perhaps our experience can serve as a point of reference for companies interested in blueprinting their own professional development plan.

A Personnel Development Program

Early in the history of the company, through the efforts of George Westinghouse and B. G. Lamme, a program for the recruitment and development of engineering graduates was inaugurated. This program has been consistently appraised and adjusted to meet changing conditions. Its primary objective is to develop competent people for all technical and management positions in the company. Nothing is more fundamentally vital to the future of our company than a sound personnel development program. Emphasis is placed on the development of broad, professional attitudes as well as technical competence. Our personnel development program consists of a number of individual programs, which may be described as a Six Point Plan.

I. *Selection and Recruitment*

The first step in building and maintaining our organization is the recruitment of capable people. The great majority of technical and professional personnel of Westinghouse is recruited at the colleges. It is not only important to have a flow of new blood into the organization, but it must be the right type. Careful screening of candidates from the standpoint of technical ability and personal qualities is considered essential. Ineffectual selection not only results in the employment of misfits who prove costly in terms of turnover and employe dissatisfaction, but deprives the company of good men who will be needed in the future. Men recruited at the colleges for positions on the first rung of the professional ladder are selected for their potential rather than their ability to become fully productive immediately.

II. *Initial Training*

The objectives of the Graduate Student Course, our initial training program, are to give the recent college graduate an understanding of the company's organization and the diversified activities open to him; to teach him methods of applying fundamental principles to the solution of industrial problems; and to assist him in finding the right type of work in line with his aptitudes, interests, and educational background.

These objectives are accomplished through a series of coordinated work assignments, technical and professional conferences, and individual counseling. In brief, the program is a process of matching men and jobs and providing each man with the tools to move forward. It is a system in which the individual plays a leading role in determining the nature of his career.

III. *Follow-up Training*

Continuous training on an informal basis is essential to the maximum development of a young engineer. Upon placement in a department, he is assigned to a senior engineer, who understands the problems confronting a new man. A sympathetic approach does much to bring out the good qualities and remedy shortcomings.

As the young engineer gets a "feel" of the work, he is encouraged to assume responsibility as fast as he can handle it. Flexibility in arranging jobs makes possible the use of the individual's abilities at the highest level. Job rotation broadens his knowledge, and prepares him for advancement along technical or supervisory lines.

IV. *Continued Education*

Continued education is an integral part of the Westinghouse development plan. Professional employes are urged to include both formal and informal education in their own self-improvement program. Supplementing undergraduate education with additional study is of particular value to a young engineer. It broadens his background, keeps him mentally alert, and provides a foundation for professional growth. Educational pursuits also give a sense of personal accomplishment.

The Graduate Study Program, affiliated with ten universities, offers unusual opportunities to combine graduate work with the regular job. A majority of the graduate-level courses are offered in the late afternoon or evening, although the well-known Design Schools, started by B. G. Lamme in 1912, are daytime programs. The fields of study include mathematics, science, engineering, and business administration. Our engineers are encouraged to avail themselves of classes in business management, the social sciences, and the humanities, as well as technical courses. The company pays a substantial part of the tuition costs.

V. *Professional Activities*

Participation in engineering societies and civic organizations does much to develop the well-rounded individual required in our organization. Contacts with people with different backgrounds and interests broaden the young engineer's viewpoint. All technical graduates are urged to continue their engineering society affiliation. Committee work engenders a sense of belonging and promotes a professional consciousness. The preparation and presentation of papers build self-confidence and give the young engineer recognition in the company and throughout the profession. Management sets the example by actively supporting the societies.

VI. *Management Development*

The management talent search is a must for every company. Under our Six Point Plan, we do not have to start from scratch to develop executive leadership. The program outlined in the foregoing paragraphs provides the foundation and brings potential leaders to the attention of management. Our point VI, therefore, concerns itself with grooming men of demonstrated ability for positions of increased management responsibility.

Development at this level is, by necessity, individualized. An engineer normally becomes a "specialist." To manage capably on the higher levels, he must be a "generalist." Through horizontal promotion, special tours of duty, and leadership training conferences, broad-gauge managers are developed. Decentralization of operations and the "divisional type" of organization contribute to the development of competent executives.

The Six Point Plan is fundamentally sound. Its basic principles are applicable to any company, large or small, although the details of operation and methods employed must be tailored to fit the individual company.

Meeting Individual Needs

The comprehensive program I have outlined gives careful consideration to the development of personal qualities essential to success. Here we are dealing with intangibles which at once pose the most perplexing and at the same time the most challenging questions in personnel management. Although people do not differ from one another much, the small differences are of great significance. Success in integrating this human equation is difficult to measure. Nevertheless, in its efforts to increase the technical competence and industrial "know-how" of the college graduate, management must be mindful of the value of personal development for professional responsibility.

When we employ a college graduate, we do not hire mechanical skill or analytical ability alone. Instead, we hire an individual with many personality traits, all of which have a bearing on his performance on a job. As an individual, the employe does not park his human equipment at the shop gate when he reports for work each morning. He brings with him his hopes and his fears, his good qualities and his bad traits; they are all a part of him. His home life and adjustment in the community influence his work, and the conditions of work, in turn, affect his family relations. A live, moving organization cannot be built without due regard for the needs of the individual members of the industrial team.

The points I have just raised may seem, to some people, far removed from our discussion on industrial production and the shortage of engineers and scientists. Indeed, they are very close. Motivation, pride of workmanship, and high morale are the keys to productivity. Attitudes are significantly related to the individual's response to the industrial situation. Development programs must have high ideals which inspire the individual as well as objectives which are immediate and practical.

The development and utilization of engineering talent cannot be left to chance. It must be carefully planned. To effect a program, top management must, first, establish a clear-cut policy concerning the development of professional personnel. This policy must then be implemented, through a program which provides the machinery, to accomplish the desired objectives. An organized program not only provides the means of finding and developing particularly talented men, but it raises the general level of professional competence throughout the organization.

Whether we as a nation experience a series of Koreas, all out war, or a period of uncertain peace, we must maintain a state of total preparedness. Failure to educate, train, and properly utilize our greatest asset—potential leaders—would be national suicide.

As individuals, and as members of a profession, each of us must assume a full measure of responsibility in the establishment of sound policies for the conservation of professional talent.

Engineering English: A New Strategy

By RICHARD B. VOWLES

Assistant Professor of English, University of Florida

There are always a few engineers who find the English language both disquieting and alien. They take cold comfort in the admission of such a professional writer as Arthur Kober that the composition of a simple declarative sentence is plain torture. They may console themselves that if you have an idea words won't stand in your way; but they know better. Despite a spate of books on technical English and report writing, which happily indicate that the engineer is of all professional men most conscious of the need for accurate communication, alienation still exists between the engineer and his language. Now it is largely up to the colleges of engineering to turn this armed truce into an amiable partnership.

The University of Florida is at present experimenting with a program of technical English that may well be novel and is certainly an unusually flexible strategy. It is based on four fundamental assumptions, that

(1) the language is part of the engineer's know-how,
(2) technical English ought to be taught by technical men,
(3) it ought to be taught in the engineer's bailiwick, and
(4) it ought, so far as possible, to be integrated into existent courses.

Ideally, such a program should overcome any possible grudge the engineering student might harbor toward his language.

The English staff in engineering presently consists of two Ph.D.'s (in English): an assistant professor with a background of chemistry and chemical engineering (8 hrs.); an instructor experienced in petroleum engineering (4 hrs.); and a graduate assistant (10 hrs.). They constitute a kind of roving team, if you like; their essential function is trouble-shooting. Their dual qualification eliminates any taint of that condescension which sometimes makes the man of arts *persona non grata* in a sciences building. And well it is that sympathetic cooperation should be complete, since the college of engineering at Florida is motivating the program and supplying budgetary allotment to it.

Special Services to Engineering Departments

Each department avails itself of this service in its special way. Civil engineering incorporates a series of four lectures on basic writing problems into a seminar on engineering literature. Industrial engineering prefers to have a member of the English team spot-check a set of papers from time to time, in which case a fraction of the grade is a writing proficiency score. Chemical engineering employs what is possibly the most interesting technique. Sets of laboratory reports are intermittently turned over to the English staff for correction in matters of diction, syntax, and structure, before being graded by the professor in charge of the course. Individual conferences are later held with each student *during* the laboratory hour. Consequently the intrusion is minimized and the young engineer learns to consider his language problems in the context of plant and laboratory practice.

In addition, the English staff offers what it likes to call a kind of consultant

service. Students in the throes of a seminar report are invited to bring their problems to the staff quarters in the engineering library. If they are unable to get any life into that first letter of application, they are offered advice. Thus, *the* report or *the* letter is made a "nuclear" situation, as latterday jargonists might put it. It is *realistic*.

In short, the engineer is not asked to write the series of artificial letters, papers, and reports that the traditional course in Technical Report Writing heaps on what is so often an overloaded schedule. Furthermore, the report is not isolated from its functional relationship to engineering practice. We hope, here at Florida, that the technical elective in report writing will be obviated by this fluid program which is now operative experimentally.

Screening Test

Such a plan as this might result in a fragmentary picture of writing skill. To prevent this and to permit an early stock-taking of material, the entire junior class of engineers is given a screening test upon entrance into the upper college. During a 1½ hour period the student is required to proof a passage of semi-technical prose and to write on one of a number of controversial passages of scientific import. Each student, no matter what his performance on the test, then has a brief conference with a member of the English staff who acquaints him with the English program and indicates how it may offer effective remedy to some of his problems.

Those students deficient in English are required by their departments to attend a refresher course, not unlike what is usually and unfortunately called "remedial" English. Attention is given to the fundamentals of English in a thoroughly traditional way, except that the slant is technical and every possible use is made of the scientific analogy. For example, L. O. Guthrie's designation of the verb as the "energy center" has been found useful in a discussion of the elementary design of a sentence,[1] and other strategies of the communications course are employed. Such method is surely not pandering to the specialized mind, but wise approach to poor students who, since high school days, have been building up a hard core of resistance to their language. So far, mimeographed materials drawn from student writing and scientific journals have been used in place of a standard text. At present, no more than one month of the course is required; from that point on attendance is voluntary. The theory is that on which most reading and speech clinics operate, that enforced attendance over a period of time militates against cooperative effort, at least in such non-credit activity. This course is, however, still in a state of experimental flux.

Our program, in its entirety, is part of the upper college. It has no bearing on the freshman course, where the engineer gets exactly the same instruction as the next man. Certainly it is far from our design to give him the feeling he is especially privileged or especially retarded in his language training.

Make Language Conscious

Finally, it might be observed that the benefit of the Florida program lies not in dressing up any single technical report or in dressing down any particular student, for his faulty style. It lies, instead, in making the entire engineering school language-conscious, and in improving the texture and tonus of engineering writing. The engineering faculty have shown admirable foresight in activating a program which may, if successful, spread to other divisions of the University and may even, as a trial run, create wider interest. It is still too early to evaluate the plan in terms of teaching hours and profit and loss, but by way of interim report we might predict a modest success. The Florida plan has the strategic value of being *less intrusive* and at the same time *more pervasive* than the traditional approach.

[1] *Factual Communication* (New York: Macmillan, 1949), 212.

How Can ASEE Assist the Young Instructor?*

By HENRY H. ARMSBY

Associate Chief for Engineering Education, U. S. Office of Education

In a paper before the Southwest Section of ASEE in April 1949, a condensed version of which is scheduled for publication at an early date in the *Journal of Engineering Education*, your speaker outlined some methods by which the colleges and universities can help young instructors to grow and develop professionally. Other papers on today's program have been devoted to the problems of the young instructor in learning how to teach, and to a discussion of teaching techniques. In this paper it is proposed to discuss some of the ways in which ASEE as a Society can assist the young instructor to achieve his full professional stature.

Need for Professional Development

This discussion is based upon the assumption that the young instructor we are discussing is in the teaching business because he wants to be, and that he, like other young men, desires to make good in his chosen profession. He aspires to be the professor, the department chairman, the division director, or in some cases the dean or the college president of tomorrow, just as his classmate in industry aspires to be the chief engineer, the general superintendent, or in some cases the manager or the company president of tomorrow. Of course, not all of our young instructors will become deans, nor will all of our young engineers in industry become general superintendents. Those who reach these high positions will do so because they have grown, not merely in age, but in variety of experience, breadth of knowledge and vision, in ability to accept and to discharge responsibility, in awareness of civic duties, and the desire to help younger men. In other words, either avenue of promotion depends on professional growth.

There is widespread recognition of the need in industry for the engineer to understand not merely scientific principles and their practical applications, but also the social, economic, and political implications of his work. This recognition has been exemplified by the Interprofessions Conference on Education for Professional Responsibilities at Buck Hill Falls, Pennsylvania, in 1947, and by the findings of the Engineers' Joint Council and the Engineers' Council for Professional Development.

The successful *engineering teacher* must also develop professionally, not only as an engineer but as a leader of men, who can instill in his students a spirit of scholarship and a desire to develop themselves to the limit of their individual capacities. Furthermore, the good teacher must give to his students knowledge of how they may proceed most effectively with their own development. The primary responsibility for increasing his competence as a teacher rests, of course, on the teacher himself, but his institution and his professional colleagues are in a position to do a great deal to assist him in planning his self-development, and even in carrying it out. They should make it clear to him that he is *expected* to grow and to develop, and should give him opportunities to do so by properly orienting him to his work, by

* Paper presented before New England Section, American Society for Engineering Education, October 14, 1950.

enabling him to do post-graduate study, and by encouraging and assisting him to gain both teaching skill and industrial and research experience, the objective of which should be to improve his knowledge and broaden his interests, rather than merely to increase his income.

The Purposes and Values of ASEE

The young engineering instructor's professional colleagues as a group are represented by the American Society for Engineering Education, a Society organized with the fundamental purpose of "the advancement of education in all its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, research, extension services, and public relations." Its Constitution sets forth that the Society "shall serve its members as a common agency of stimulation and guidance in . . . the development of effective teachers and administrators, the improvement of instructional materials and methods, of personnel practices, and of administrative usages, the enhancement of professional ideals and standards, . . . and the cultivation of a fraternal spirit among teachers, administrators, investigators, practitioners, and industrialists." These are high ideals indeed and any society which can even partially realize them can feel that it is making a most worth-while contribution to the welfare of its members.

Nothing is quite so valuable to the beginner in any profession as the inspiration he can secure by close contact with the leaders of his profession. Also, nothing contributes quite so much to his advancement as the opportunity to become known to these leaders, to show them his abilities, and to make himself useful to them. For the engineering teacher, there is no way in which these objectives can be achieved better than by active participation in the work of the American Society for Engineering Education, by attendance at meetings, by joining in discussions, by preparation and presentation of papers, by service on committees, by holding office, and in general by furthering the aims and objectives of the Society. He can thus make himself known to the leaders of his profession and can be developing his own abilities in an extremely practical way. As in most human activities, the benefits he derives from ASEE well depend quite largely on the amount of effort he expends.

The Young Instructor in ASEE

In general, the instructor should start by making himself useful to his Branch if there is one in his institution, and to the Section in which his institution is situated. He has a much better opportunity to make himself known in these smaller groups than he would have by starting directly in the national group. If he earns a reputation for clear thinking, for ability to express himself well, for willingness and ability to do committee work and to hold office in the Section, he may rest assured that he will attract the attention of the national officers of the Society, and that his talents will be put to work for the benefit of the national Society, which will contribute greatly to his own professional growth. Many college administrations realize this and encourage participation in the affairs of ASEE and of the professional engineering societies. The amount and character of the teacher's participation in such affairs is frequently given consideration in making staff promotions. Of course it is understood that such activities should not be looked on as a substitute for doing committee work and otherwise cooperating with his campus colleagues.

ASEE is organized in such a way that the individual member has direct and easy access to the officers and the General Council, who administer the affairs of the Society. He is represented in two ways on the General Council, first, by a Council member chosen to represent the geographical section in which his institution is situated, and second, by another Council member chosen to represent the subject matter division of the Society with which he is affiliated. The General Council

also includes the three immediate past Presidents and the Executive Board, consisting of the Society's national officers. The Executive Board carries on the general activities of the Society between meetings of the General Council, and regularly performs certain functions which are delegated to it by the General Council.

Each member institution of the Society has a representative on the Administrative Council of the Society, and each institution which is actively engaged in engineering research has a representative on the Research Council. The chairmen of these two councils are ex officio vice-presidents of the national Society, and therefore members of the General Council and the Executive Board. This democratic form of organization makes it possible for teachers of any academic rank to become officers of the Society, members of the General Council, or officers of Divisions, Sections, or Branches.

Any member can offer a paper for presentation at the annual meeting or at a Section, Branch, or Division meeting, by merely sending a copy of his paper to the chairman of the Division, Branch, or Section concerned, many of whom rely on voluntary contributions in formulating programs. In addition to this, any member may submit a paper to the publication committee of the Society for publication in the *Journal of Engineering Education* regardless of whether or not the paper has been presented at a formal Society meeting.

How ASEE Now Helps the Young Instructor

The *Journal of Engineering Education,* the official publication of ASEE, constitutes a veritable storehouse of useful and inspiring articles about various aspects of engineering education. The young instructor might well be a "cover-to-cover" reader of this journal, since even articles about some other phase of engineering education than the one in which he is particularly interested contain valuable suggstions which the young instructor can utilize in his own classes. An outstanding example is found in the article entitled "Interdepartmental Cooperation for Better English" in the June 1950 issue, in which Professor Mack of Lehigh University outlines the methods used in his institution in an organized effort to have every teacher actually *do something* about improving the quality of English used by his students. Any young instructor who reads this article should be inspired by it, and many will probably wish to adopt some of the methods discussed. Furthermore, the idea of interdepartmental cooperation which is set forth in this article has valuable implications for other parts of the engineering curriculum as well as for the courses in English.

The Society has published a "Manual of Effective Teaching," which was prepared by a Society committee. This Manual contains many valuable suggestions which will greatly assist the young instructor in organizing his work, in planning his courses, and in self-evaluation of his effectiveness as a teacher.

The Society each summer sponsors one or more summer schools for engineering teachers. Each summer school is sponsored by one of the subject-matter divisions of the Society, and is devoted to lectures, discussions, and exercises looking toward the improvement of the teaching of that particular part of the engineering curriculum. The primary emphasis of these summer schools is on the development of the teacher, and in general technical engineering papers are avoided.

Since April of 1949 ASEE has had a national Committee for Young Engineering Teachers, under the chairmanship of Professor F. L. Schwartz of the University of Michigan. This committee was appointed because of a feeling on the part of many that there was a need for some mechanism by which the younger members of the Society could find more direct assistance, expression, and responsibility in the advancement of themselves and of the Society. The committee has defined its objectives as:

A. An understanding of the general goals and responsibilities of the *two* professions which every teacher of engineering follows, engineering and education.
B. Orientation into the history, the lore and the "unwritten laws" of the dual profession of engineering education.
C. An acquaintance with the most effective instructional materials and methods, with methods of evaluating student achievement, and with the elements of counseling and student guidance.
D. Guidance in his personal professional development both as an engineer and as a teacher.
E. A means of exchanging ideas with his contemporaries.
F. Stimulation.
G. Dissemination of knowledge.

Two meetings of younger teachers were held in connection with the 1950 annual meeting of the Society in Seattle. Professor Schwartz has suggested that if sufficient interest develops among the younger teachers the group may at some future date apply for Division status in the Society.

ASEE now has a Committee on the Improvement of Teaching under the chairmanship of Vice President Grinter. It is hoped this Committee will develop some definite, concrete, and worth-while procedures which the Society can use and endorse toward this end. The Society has also been asked to name participants in a national conference on the improvement of college teaching, which is being organized jointly by the American Council on Education and the United States Office of Education.

There is no reason why a Section may not have similar committees, and other Sections might profitably follow the example of the National Capital Area Section in its annual meeting last spring. The theme of this meeting was "The Improvement of Engineering Teaching." Papers were delivered by the Dean of a College of Education, the head of a Department of Psychology, and a Training Specialist in the U. S. Navy Department who was formerly a Professor of Speech. These papers were all top-notch presentations and were followed by active discussion from the floor, in which many of the younger members of the Section participated. The members of the Section considered it a highly successful meeting, and felt that it served as an inspiration to all present to really try to *do something* about improving themselves as teachers. The paper by the Dean of Education has been sent to the publications committee of the national Society with a recommendation that it be published in the *Journal of Engineering Education.*

What More Can ASEE Do For the Young Instructor?

Some ways in which ASEE, both nationally and in the Sections, can still further help the young instructor might be suggested.

1. More local Branches could be established to serve as forums for both the younger and the older members of the profession, with special emphasis on stimulating younger instructors and broadening their horizons.

2. More summer schools for engineering teachers could be conducted, with major emphasis upon such subjects as teaching methods, teaching aids, evaluation of student achievement, teacher rating devices and methods, and evaluation of effective teaching.

3. National or local committees could prepare and circulate technical and cultural reading lists for young instructors.

4. Groups of young instructors might be encouraged to study the history of engineering.

5. National and sectional meetings might devote more time to discussions of the engineering teacher as a technical writer, as a consulting engineer, as an educational administrator, and of his relations with industry.

6. National and local committees might be appointed to study the implementation of the aims and objectives of the Society, stated in Article I of the Constitution as "the adjustment of curricula and educational processes to changing conditions," "the development of effective teachers and administrators," "the improvement of instructional materials and methods, of personal practices, and of administrative usages," "the coordination of institutional aims and programs," "the cultivation of a fraternal spirit among teachers, administrators, investigators, practitioners, and industrialists."

Most of these services *can* be rendered effectively by Sections and Branches of the Society as well as by the Society as a whole. If the Sections and Branches *will* render these services, especially to their younger members, they will strengthen not only the individual member but the national Society and the institutions it serves.

Conclusion

The American Society for Engineering Education is doing a great deal to assist the young instructor to attain true professional status. The Society can do more than it is now doing. It can be especially effective in the Sections and Branches because of closer and more intimate contacts. The ultimate effectiveness of the Society in helping young instructors will depend in the final analysis on how much the young instructors help the Society.

In the News

National Science Foundation Grants

The National Science Foundation has made travel grants to four American mathematicians to permit their attendance as members of the United States delegation to the First General Assembly of the International Mathematical Union in Rome, Italy, March 6–8, 1952. These are the first travel grants to be made under the Foundation's program to provide for the attendance of American scientists at international scientific meetings.

Russell S. Poor, Chairman of the University Relations Division of the Oak Ridge Institute of Nuclear Studies, has taken a year's leave of absence to join the National Science Foundation. Dr. Poor will head the Research Education Section of the Division of Scientific Personnel and Education of the NSF.

The National Science Foundation has announced approval of 28 research grants, totaling $410,000, in the field of the biological sciences. This is the initial group of grants which will be made under the Foundation's program for support of basic research in the sciences.

"Life is Short. We Need to Make it Broad"

By CLEMENT J. FREUND

Dean, College of Engineering, University of Detroit

The late and revered Robert Doherty had many trenchant things to say about engineering education. For example, "One of the greatest deficiencies of engineering courses in this country, in my opinion, has been the lack of cultural balance. Where such a balance has not existed the student's intellect has been literally starved for the vitamins of humane appreciation, thus leaving him with what might be called technical rickets —a wooden interest in things outside his technical field."

Whenever the chairman or the president, or even the chief engineer of any one of our great American corporations stands up to talk about engineering education, he pounds the table and insists that engineering education must be broad.

And we engineering educators eagerly nod approval. We read about the need for broad engineering education in the "Report of the Committee on Educational Survey" of the Massachusetts Institute of Technology; we read about it in the "Report of Committee on Engineering Education After the War," in the "Report of Committee on Aims and Scope of Engineering Education," and in the "Report of Investigation of Engineering Education." And we expect to read about it when Dean Hollister's new committee reports to the Engineers' Council for Professional Development. Everywhere, all the time, our thoughtful leaders talk to us about the necessity for broad education. And we say to ourselves, "I agree with them exactly, only they say it so much better than I could."

Practice What We Preach

But do we always "suit the action to the word"?

Observe a typical engineering dean. He has just returned to his office from a national engineering convention at New York or Washington or somewhere. In the course of his address at the convention he raised his arm on high and declared in a booming voice, "If our students are to attain to their proper stature in their engineering careers, we must see to it that they get a broad grounding in the humanities as well as in technology." There was generous applause.

First in the line of visitors to the dean's office, now that he is back, is the chairman of his department of electrical engineering. The chairman is looking for an assistant professor. The chairman is speaking. "Here is a man with about five years' teaching experience. He has a master's degree, and earned a degree in liberal arts before he ever studied engineering; philosophy or political economy or something of the sort. He has been chief engineer in a company which manufactures all kinds of control equipment. He has had experience in the telephone game, and he has even had a try in power utilities. He is widely travelled and has had his finger in a great many civic pies. He is highly recommended."

The dean displays no enthusiasm. He says "Humph."

The electrical engineering chairman has not succeeded in assembling too many applications, but he proceeds hopefully. "How about this fellow? He has a bril-

liant record. He's been teaching about five years too. He studied for the master's degree and then went on for his doctorate. He prepared a masterful dissertation on 'Substation Protection by Power Carrier Methods.' Since then he has been busy with research. This is a schedule of his publications. The titles all refer to substation protection. He seems to be something of an authority."

"That's more like it," remarks the dean, and a bright gleam appears in the eyes of both men.

Could not the dean and the chairman be any two of us engineering educators? We talk big about broad education, but we seem to forget all about it when we hire or promote faculty men; or when, in our early years, we are getting ourselves ready.

Or perhaps we don't forget; perhaps we have thought the matter through and have made the following assumption:

We can accomplish the broad education of our students by making them study a variegated pattern of subject matters; even when each item of subject matter is taught by a specialist in his restricted field of electronics or economics or fluid flow.

I strongly suspect that the assumption is not valid.

Broad Outlook Necessary

Although I am by no means qualified in the philosophy of engineering education, I find myself again and again confronted by the question: can teachers turn out broadly educated young engineers if the teachers themselves are not broad in outlook, in experience and in education?

Perhaps I may be permitted to cite my own experience; after all, it is the only experience I have had. In my college days I pursued courses in political economy, history, economics, psychology and the like. I can testify that there was no abundance of broad or liberalizing value in these courses as such; nor in any combination of these courses.

The broad or liberal influence was exerted by the liberally cultivated teachers; men who had learned about the great leaders of all ages, who understood the motives and ideals which inspire the inhabitants of the world; men who had studied and worked with men and women of many different backgrounds and experiences in various territories and environments.

Possibly we have been spellbound by the glamour and fascination of the graduate schools. Graduate study and research in engineering are quite the fashion. If any one of us is not exercised about them, he loses a vast amount of face. This is as it should be. The graduate schools and research centers are the inspiration and the fountain head of much of engineering progress. And so it is, I suppose, that we hire specialists who can teach the graduate courses; and we fondly hope that broad undergraduate education will come out of it all, somehow, as a by-product.

But is not the tail, perhaps, beginning to wag the dog? Last year there were 18,522 graduate students of engineering in the United States; however, there were 142,954 undergraduates.

Should we not beat up our courage before long and squarely face the issue? Have not the objectives and the methods of graduate and of undergraduate instruction become so divergent that one man can hardly be expected to do a good job in both?

In the graduate school, we train the specialist * in technology; in heat measurement, in viscosity or in vibration. The narrower and more restricted the field of work, the more expert, presumably, the student will become. And the narrower and more restricted the field of the teacher, the more effective, presumably, will be his teaching.

Undergraduate Teachers Should Be Versatile

In the undergraduate college of engineering, on the other hand, we strive,

* This appears to be prevailing practice in spite of occasional insistence in some quarters upon broader graduate programs.

principally, to develop a man who proposes to become an engineer. We want him to have a grasp of the basic or elementary principles of engineering, and to know how to apply these principles to any ordinary situation to which they are pertinent. And we want him to grow into a citizen of broad understanding, information and interest. Hence, the ideal undergraduate teacher should doubtless be versatile in his engineering competence and experience, and a cultivated man of the world.

It may well be that we shall never fully succeed in fitting together graduate and undergraduate instruction. But why not try? In October, President Killian addressed the annual meeting of the Engineers' Council for Professional Development. He told them that the teacher of humanistic subjects must have status and privileges in the schools of technology equal to the status and privileges of the teacher of science and engineering. Should we not paraphrase his injunction and insist that the versatile and broadly cultivated engineering teacher shall have status and privileges equal to the status and the privileges of the technological specialist?

If we could accomplish that much, the solution of our problem might at least be in sight.

College Notes

A grant of $400,000 to the **Massachusetts Institute of Technology** from the Edwin Sibley Webster Foundation to establish an Edwin Sibley Webster Professorship of Electrical Engineering was announced by Dr. Karl T. Compton, Chairman of the Corporation of the Institute.

A special program in the colloid chemistry of Elastic High Polymers in Science and Industry will be held at the **Massachusetts Institute of Technology** from June 16 to July 5.

The course is planned to present to those actively engaged in the production and industrial applications of natural and synthetic elastomers the latest information on the chemical composition, structure, and production of elastic high molecular colloids of organic and inorganic composition.

The appointment of Malcolm S. McIlroy as assistant dean of the College of Engineering at **Cornell University** effective July 1, was announced by President Deane W. Malott. McIlroy was graduated from the electrical engineering course at Cornell in 1923 and received the doctor of science degree at M.I.T. in 1947. Before joining the Cornell staff in 1947, he was with the General Electric Company, Schenectady, and the Central Hudson Gas and Electric Corp., Poughkeepsie. He also taught at M.I.T. and during the war was assistant director of the M.I.T. Radar School.

Development of an educational program designed to spread information on the facts and future of atomic energy was announced by **Michigan State College.**

College officials said the first phase of the program would be a two-day conference titled "Atomic Energy and the Future" scheduled May 20–21.

"The Infinite Sphere"*

By ALBERT E. SANDERSON

Associate Professor of Drawing, Northeastern University

In order for a student to become proficient in the use of Multi-View Drawings it is necessary that he understand thoroughly the relationships between the various views. I have long been in search of a better way to illustrate these relationships.

The classical method for obtaining the necessary views is through the medium of the "Glass Box." In this method the object to be drawn is placed at the center of the box. Projectors are then drawn from the object, intersecting the transparent sides. These points of intersection are connected to form the views and the sides of the box are then developed.

It must be conceded that this method, though thoroughly artificial, is a convenient and satisfactory method of obtaining the principal views.

Though considerable mental concentration is required, the student is generally able to visualize similar steps leading to the solution of primary auxiliary view problems.

It will, however, be generally admitted, I think, that in the matter of illustrating oblique (i.e., secondary auxiliary) views the "Glass Box" Method leaves much to be desired. The task of visualizing the unfolding of two auxiliary planes is a difficult one even for a drawing instructor and an almost impossible one for an inexperienced student.

Direct Method

Of recent years the Direct Method of teaching Multi-View Drawing has achieved some popularity. This is the method in which the observer looks directly at the object and draws that which he sees, using any preferred position of the eye. This method does away with the planes of projection entirely, employing only reference planes from which to take measurements when working between views. This is the method in use at Northeastern and it has been found particularly satisfactory in correlating Descriptive Geometry with some parts of the Engineering Drawing Course.

In using the Direct Method, as mentioned previously, the eye of the observer is free to move to any desired location. In order for the rays to approach parallelism the distance from the object is generally assumed to be infinite. As one visualizes this roving movement of the eye the surface generated is seen to be that of a sphere.

I have designated this spherical surface as the "Infinite Sphere." In the pages which follow I have drawn the sphere and plotted views upon its surface. It is, at least from a theoretical standpoint, possible to illustrate in this manner any multi-view problem in Engineering Drawing or Descriptive Geometry and to have the entire solution visible in pictorial form. We are thus relieved of the necessity for traveling around corners to get from one view to another and all views assume their proper spatial relationship. What is most advantageous is the fact that the student

* This paper presented at the Drawing Conference of the Fall Meeting of the New England Section of ASEE at the University of Rhode Island on October 13, 1951.

is able to look at a pictorial of this type and to connect it without difficulty with his drawing.

With the eye at infinite distance the radius of the sphere also becomes infinite, so that, within the limited area of each view, the surface may be considered a flat plane.

Illustrations for Classroom Instruction

The drawings which follow are samples of the type of illustration which may be used in classroom instruction.

Fig. 1(a) shows the three principal views of a cut block. There is no definite orientation to the pictorial. Each of the views may be made to serve as top, front, or right and left side views by rotating the page. The ninety degree relationship between views is thus clearly established. This picture also shows, for example, why it is possible to draw a side view either in its normal position adjacent to the front view or in the "second position" adjacent to the top view. Fig. 1(b) is a multi-view drawing of the same object.

Fig. 2(a) shows the principal views together with a primary auxiliary view. A reference plane has also been drawn in. Note that this plane touches the right hand side of three of the views and in each of these the plane is seen on edge in Fig. 2(b). This illustration is useful in demonstrating that the width of the auxiliary view may be obtained from any view in which the reference plane is seen on edge. As in the previous illustrations there is no definite orientation to the pictorial. By rotating the figure the three common types of auxiliary views may be illustrated and in each position the reference plane will be seen in its proper place.

Fig. 3(a) shows that it is possible, on the surface of a sphere, to show the principal views, a primary auxiliary view and an oblique view, together with the necessary reference planes and have the picture easily readable. It also seems much simpler to connect a pictorial of this type with the working drawing than by previous methods. This illustration may also be rotated to show how the edge views are obtained when horizontal, frontal or profile principal lines are used as the direction of sight.

It is believed that this type of illustration will be found most useful when made up into permanent drawings for display

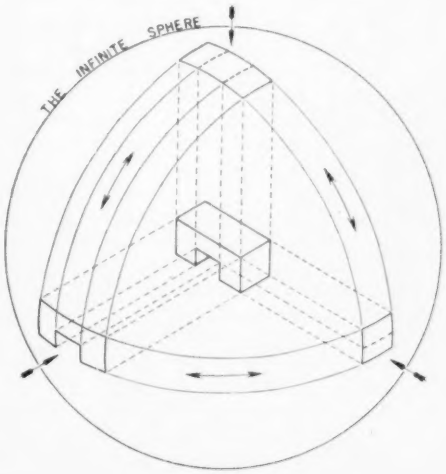

FIG. 1(a)

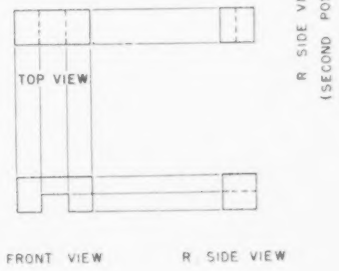

FIG. 1(b)

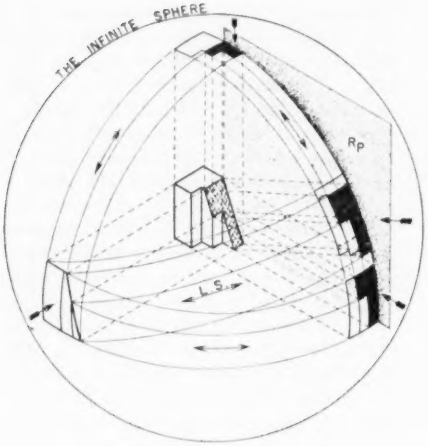

FIG. 2(a)

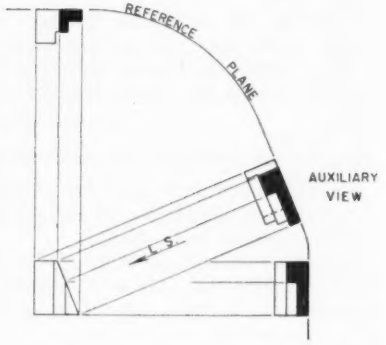

FIG. 2(b)

purposes. It is not easy for an instructor to sketch on the blackboard a problem on the surface of a sphere unless he has made a preliminary trial, since the proper relationships between views are not easily obtained.

This idea was suggested by the Celestial Sphere which is used in Astronomy—particularly that phase of Astronomy used in Higher Surveying. It may be shown that certain problems in Descriptive Geometry have a close relationship with

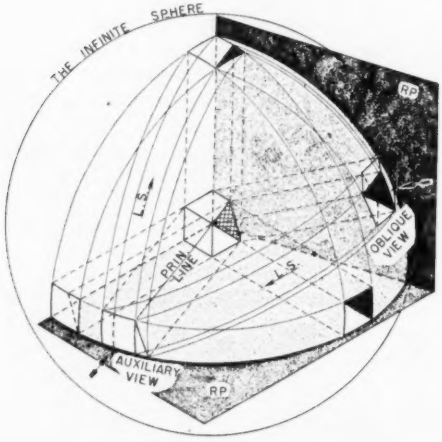

FIG. 3(a)

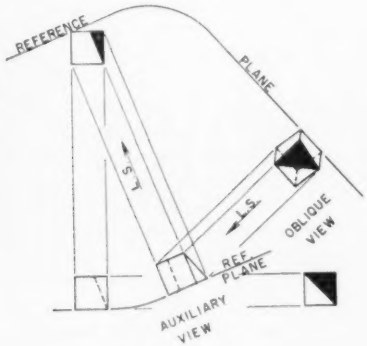

FIG. 3(b)

similar problems in Spherical Trigonometry when represented on the surface of a sphere. This is an angle which would seem to be worth further investigation.

Conclusion

In conclusion, let me say that what I have presented here represents no cure-all for lack of aptitude, but it does, in my opinion, present the basic principles of Multi-View Drawing in better fashion than by previous methods. I have been very much surprised to find that the "Infinite Sphere" has been as much help to the teacher as to the student.

As a further extension of this idea it seems likely that solid or transparent plastic spheres might be used to advantage with the problems worked out on the surface. A sample sphere may be seen on the platform.

It is to be hoped that drawing instructors in other institutions will give this method a trial and that we may have a worthwhile discussion of its merits at some future date.

College Notes

L. E. Grinter, Vice President of the ASEE and formerly Vice President of **Illinois Institute of Technology**, has announced his appointment as Dean of the Graduate School and Director of Research at the **University of Florida.** At Gainesville, Dean Grinter will assume responsibility for a graduate student body of 1500 students and a research program involving an expenditure of several million dollars annually. He expects to take up his new duties at the beginning of the fall semester. For the past two years Dr. Grinter has been consultant to the Board of Control for Southern Regional Education and is now a member of the Board's Commission on Graduate Studies. Dr. Grinter came to Armour Institute of Technology in 1937 to organize the graduate school and to serve as its first dean. With the merger of Armour and Lewis Institutes he became the first vice president of Illinois Tech and was responsible from 1940 to 1946 for the Institute's coordinated educational and research program. During this period Illinois Institute of Technology developed its College of Liberal Arts, its Extension Division for educational cooperation with industry, its scientific research options, its management options, and its industrial safety program. Several major departments were also established including metallurgical engineering, naval science, biology, food engineering and psychology including the Institute for Psychological Services. The distinction of the faculty assembled under the leadership of Dean Grinter has attracted national attention.

Since 1946, Dr. Grinter has been research professor of civil engineering and mechanics at Illinois Tech. He has also served as chairman of the Panel on Equipment and Construction for the Department of Defense in Washington and in this work he has had the assignment of developing cooperation between the Army, Navy and Air Force in the field of research. Since 1948 he has been a consultant to the Research and Development Board on the resistance of structures to Atomic explosions.

The writings of Professor Grinter include numerous scientific monographs and a half dozen books in the fields of structural engineering and mechanics. He also writes articles on graduate and undergraduate education. Under Dr. Grinter's direction two major ASEE committee reports are now approaching completion—one is a study of graduate education and the other a report on improvement in the teaching of undergraduate students. In this Society he was responsible for the organization of the Graduate Division and served as its first chairman.

The Place of Cooperative Education in Modern Industry*

By C. R. OSBORN

Vice-President, General Motors Corp.

The subject of my remarks today is "The Place of Cooperative Education in Modern Industry." Because of the uneasiness which is evident on every side, among our students and, in fact, every strata of our people, brought about by world conditions and our internal situation, perhaps I should talk about cooperative engineering and its place in our modern world. Such an all-encompassing subject provides a wealth of material to consume hours of your time and not too profitably either, because I must admit that I am as confused as many of you on the proper answers to these complexing problems. However, they will have to be dealt with and undoubtedly will be dealt with by some of the graduates of our cooperative schools, who by reason of their character, their method of education and their habit of dealing honestly and directly with facts, are peculiarly well equipped to assume these responsibilities industrially, politically and otherwise.

Living in a World of Change

I am sure of one thing which permits of no argument, that we are living in a world of phenominal change and the sooner an individual is brought face to face with realities, with facts as they are, the more we can expect of him and his valuable contribution to himself and to the world community. Speaking from a technological point of view, no set of text-books can possibly be kept abreast of the rapid phenominal changes as they have occurred over the past few years. To give you a few examples; several weeks ago I visited our Allison Division where, among other products, we make turbo-jet engines. I was shown a new engine which had just completed it first few hours of operational tests and had proved to be one of the highest thrust engines ever to have been designed and produced in the world. It had not then started what we term its "type test." Later in the day, our engineers showed me some new designs which when completed would, beyond any question of doubt, obsolete the engine that I had just seen. In fact, it is a common saying among our Allison people, working in this jet engine field, that by the time you have an engine through the Model Shop and can see it in the flesh, it is already obsolete. How can such rapid change in progress be adequately covered in our text-books.

Today in our diesel locomotives, we regularly obtain 750,000 to 1,000,000 miles on our pistons and cylinder walls before re-boring is necessary. A few years ago we were quite happy when we realized 100,000 miles before replacement.

One of Mr. Kettering's favorite stories relates to an experience he had several years ago. He happened to accompany one of our noted educators through a display set-up in a Detroit hotel in connection with an SAE Convention. We had one of our new diesel engine pistons in this dis-

* Presented at a special Centennial event entitled, "A Day on Co-operative Education" at The Technological Institute, Northwestern University, November 8, 1951.

play. The educator stopped and examined the piston very closely and finally asked Mr. Kettering if it had ever been used in any application. Ket replied in an off-hand manner, "Oh yes, it is used in all of our diesel engine applications to railroad motive power." The educator then inquired as to how much success we had with this piston; and when Ket replied it was tremendously successful, his friend stated that it just couldn't be so. He pointed out numerous design features that were in conflict with every known principle of good piston design and finally said, "Ket, if that piston works, we will have to throw away every text-book in the country" Ket said, "Well, John, the engine that uses this piston hasn't read the text-books." He said, "All we did was to act as an errand boy. We made up one set of pistons, put them in the engine, ran them a while and asked the engine how it liked them. We took them out and looked at them and the answer was quite evident—the engine didn't like them. We made another set and the engine liked them a little better. Acting as errand boy we trotted back and forth with new sets of pistons until finally the engine said, 'I like this piston design just fine,' and that, my friend, is the piston you see there." Ket then said, "John, by the way, have you ever been a piston in a diesel engine?" And that ended the argument.

In our gasoline engine designs, chemical improvement in fuels, or, in other words, higher octane gasolines obtained through advanced cracking processes and additives such as ethyl, have until recently provided the entire foundation for our development work in obtaining increased horsepower and improved economy in engine performance.

Now we are accomplishing the same result through unusual designs of compression chambers and piston crowns, the results of which we can and do measure in what we call mechanical octanes. Mechanical octanes are just as effective as chemical octanes and save the vast sums of money required to obtain high chemical octanes in fuel. We are now looking forward to engines with compression ratios of 10 to 12, without having to pay the excessive investment penalty of very high chemical octane fuels; and which in turn will so improve the economy of our engines that they represent the equivalent of vast discoveries of new oil basins. Again, so much progress is being made in this field that the text-books cannot currently be kept up-to-date.

In the chemical field, materials are being created which displace cotton, silk and wool at a lower price, and with better functional values.

In the atomic field, no one knows—good or bad—what is in store for us. We do know, however, that if the use of atomic energy can be confined to peaceful ends, unbelievable results will be accomplished in new applications of this powerful source of energy.

A Great Change in Industrial Relations

There is also a great change which has occurred in the last decade in our human or industrial relations, as we call them. All of our young men starting a career in any type of industrial enterprize would do well and, in fact, must keep abreast of the thinking and attitude of our working people. They must recognize that their ideas, aims, and ambitions will have to be dealt with fairly and intelligently and politically with the world condition such as it is today.

It is to be hoped that our Universities through their curricula will provide the proper emphasis on the world's political problems to insure at least an understanding of the significance of world events as they occur; and with this understanding, that this host of young men, turned out by our Universities everywhere, will assume their rightful and proper responsibility in the selection of their leaders to deal intelligently with these all-important world and internal political problems.

Summarizing, it does seem to me, with the rapid change in every field of human activity which is so prevalent today, that we have an important problem to deal with, in our educational system which can-

not be adequately handled by the normal college curricula. I do believe, however, that our cooperative system of education provides an important and unique opportunity for the young man starting a career today, an opportunity to keep abreast of these developments in the specialized field he may select and an opportunity that is not so readily available to him in any other way.

I don't want to leave the impression that I discredit the books or educational methods now in use in our Universities, cooperative or otherwise. After all, the jet engine as we now know it didn't appear in full bloom as a finished product on our design tables and Model Shops overnight. Our engineers obviously had to have a thorough grounding and understanding of basic thermo-dynamics which they acquired in some University, before they could even understand what goes on in a jet engine. And, even so, it is generally recognized, we still know very little of all the things happening in a jet engine when it is turning out such tremendous horsepower. I should like to mention in passing, however, that the youngster studying thermo-dynamics in a University has a tremendous advantage, if, in his shop work he is exposed to jet engine design and performance, concurrently with his University studies. I did not have this opportunity when I was in school, and thermo-dynamics as a result was a pain-in-the-neck to me instead of the very vital and tremendously interesting study it could have been.

My experience with hydraulics was the same. When we started this course, our professor stated that we could not expect to memorize all of the hydraulic formulae that we would encounter in the book; but he did state that he wanted us to understand the formulae and its application, to the extent that when we had a problem to be solved, we could go to the book, select the proper formula and apply it correctly. Therefore, whenever we had an examination, we were permitted to use any books or notes that we had available. The President of Purdue University told me of an experience that they had had in one of their hydraulics examinations. In their school they also permit their students to use any text-books or notes they have available in answering their examination questions; in fact, their hydraulics professor told his class that they could use anything in the examination that any student could carry into the room on his back. The next day, one of the students came into the room carrying the previous year's hydraulic genius on his back.

But to return to my point, I think the cooperative school should give to their students just as thorough education and understanding, as a full-time school, on all of the basic subjects, such as physics, mathematics, chemistry, electricity, strength of materials, machine design, and all of those basic sciences and laws on which all research and design progress, must be based. In this respect I have no complaints or suggestions to offer, because with the faculties we have in our schools and with our advanced text-books, I think that our students' education is in good hands.

Nor do I want to leave the impression that I discount the tremendous value of our straight-time schools and the product they turn out, such as MIT and all the other fine educational institutions which, in fact, constitute the great proportion of our technical schools. We must not discount the fact that any engineering graduate, to be worth his salt, must understand the basic sciences, must of necessity, by reason of his engineering education, learn to think straight and to think honestly. And it does appear to me that schools operating on a full-time basis have a better opportunity within their student and post-graduate body, to better carry on basic research activities, for which there is a very great need in this country by reason of our political and economic position of world leadership.

The cooperative school need not shy away from basic research; nor do they indeed. But it seems to me that they tend more toward that equally important field of applied science.

Now, since I have indicated that I feel an excellent job is being done in the purely educational field in our cooperative universities and have stressed so much the inadequacy of text-books to keep pace with the rapidly changing field of great engineering complexity and advance, you might reasonably ask what do I propose doing about it. I have two suggestions to make; one of which has to do largely with industry's responsibility in this educational job and the second with a proposal to the universities for their consideration.

Suggestions for Cooperating Industries

While a Co-op student at the University of Cincinnati, I spent the first year and a half in a Heat-treating Department, because the Foreman liked my work and the school coordinator couldn't do anything about it, nor could I. I learned all there was to know in this department in six weeks and should have been moved on. Perhaps this type of situation has improved importantly over the years, and I am sure, it has; but I am equally sure that, as Plant Manager, I could have seen to it that a much better job was being done in intelligent rotation of jobs for our co-op students, so that they would have been provided with a thorough and well-rounded education with up-to-date knowledge of engineering and manufacturing practices that cannot be obtained in text-books, and which actually was the objective that Dean Schneider had in mind when he created the Cooperative Plan of Engineering Education. I have the following suggestions to make, and I make them with the knowledge that some of them have been part and parcel of the cooperative method of education for more than fifty years; but I repeat them because I know that they must be emphasized and re-emphasized in your contacts with industry if we are to realize maximum advantage from the cooperative scheme of education. They are as follows:

1) Co-relate shop work with the University curricula to the maximum degree, subject by subject and year by year.

2) Insure that the student spends a goodly portion of his time as a workman so that he becomes familiar with their thinking, their attitude, and their ambitions. He should likewise be required to become thoroughly familiar with the Labor Contract, its concept and operation.

3) During his first two years, he should cover production routings, tool design, machinery application, engineering, drafting and design, in fact, all the basic functions of a normal engineering and manufacturing activity. His training in the factory should be just as intense, well planned and well ordered as it is in the school. A youngster educated in such surroundings, if he is an engineer at heart, will eat it up. If he isn't, the sooner he finds it out and shifts over to another activity, the better off he will be. It is my observation that in Co-op schools we have the outstanding advantage of correcting the errors of the parents, who, because Dad is an engineer, young Johnny must follow in his footsteps. And except for the Co-op schools Johnny, who is a fine lad and wants to please his parents, because of the money they are spending on him, doesn't find out that he is not an engineer, and doesn't like engineering, until after their money is spent, the four years used up and he gets out in the shop and starts to get his hands dirty. It has been my observation that most of our lads in Co-operative schools want to be engineers. All I am saying is, let's take maximum advantage of that fact and not discourage the embyro-engineer by putting him in the blue print room and keeping him there, because he is very adept in learning how to fold up a blue print in the complicated fashion we use. Let us be sure that they do get—the KNOW HOW—the one thing that pays off—for them and for us.

4) During his last two years, he should divide his time between production processing, which will provide him with a thorough background in modern machine tool design and application and an appreciation of the progress currently being made in technological advancement,

5) and advanced engineering design. He should be associated, to the maximum degree possible, with the group or groups of engineers and designers who are responsible for the conception, design and test of the most advanced engineering and research projects. These last two years are particularly important in the training of our young men, so that we can effectively bridge over the gap between our basic theoretical training in the schools and the tremendous advancement occurring each year in the technical sciences.

6) Finally, and to repeat, see that the cooperative plan of education is administered in accordance with its original concept, without any intention of paternalistic attitude or favoritism. Industry must watch and control the activities and progress of the student in the factory and laboratory just as closely as their time, activity and results are controlled by the faculty in the school. Anything short of this requirement defeats the purpose and value of this very important and advanced type of education.

Suggestions for Cooperative Plan Colleges

My second major point, as I have mentioned, has to do with a suggestion to the school. I am very much in favor of education, where opportunity permits, by case example. Case example in my vocabulary is another way of saying, "Education by recount of experience." Let me explain my idea of how this can be effectively introduced in our educational scheme of things, if it is not already in existence in our schools.

I would set up a *case example* one-hour lecture course per week for the entire senior year. Northwestern University has Co-ops, as we call them in Cincinnati, working at a number of different plants throughout this area. One of these plants has developed a new type of piston, which I have already mentioned. Another, a new advanced type of compressor for a jet engine. Perhaps another has a new method of making soap. Another, a new material to replace all of the insulating materials, with many times the life and effectiveness of the old materials. Another, a new manufacturing method, which has reduced productive hours by 50%. Another, an executive who has just returned from an important Washington or European post, who has an unusual fund of knowledge on our foreign and domestic problems and policies. I know that these industries with whom you are in regular contact have a fund of knowledge touching every aspect of advanced manufacturing practices, modern design, experiences in industrial and human relationship, which, if made available to our students in the form of papers or lectures by responsible people within industry, could become the nucleus and foundation of a new course of tremendous interest and value to our engineering students. This activity, too, would provide a long step forward in bridging over the gap between our basic educational activities and the progress currently being realized in our modern industrial engineering and research activities. Perhaps you have such an activity here and in other schools throughout the country; if so, I am sure you would confirm my conviction that such a program can be made of vital importance in our educational problem in this age of rapid change and development.

A few years ago, the maximum power used in an airplane engine was about 450 hp. Today, when we discuss our products and future plans, plans which must become an actuality within a few years, horsepower figures per individual plane are nonchalantly discussed at 35,000 to 50,000 hp. Most of the men doing this work are in their early 30's. Following our discussions of the product, we usually go out to see one of these new engines in operation. The buildings over your head and the ground under your feet shakes and your stomach feels like it is taking off. You look around at the young engineer who unleashed all of this tremendous horsepower to see if he is impressed as you are. He is totally unconcerned; and the thought always goes through my head,

"Father, forgive them; for they know not what they do."

A few days ago a group of us visited the new Du Pont Research Laboratories. One after another, young men, most of them in their late 20's or early 30's, described their individual projects and activities. It was an amazing experience to see the things which were being done and to hear of their confident expectations for the future.

Conclusion

I might sum up my remarks by emphasizing that in these days of phenominal change, we cannot expect the universities through their faculties and text-books to assume the entire responsibility for fully equipping our youngsters for the job which lies ahead. Industry, too, has a responsibility and a very important stake in this educational job.

In our position of world leadership, it is difficult for us to know how well we are faring in the area of political activity, but I believe we can all agree that with this combination of our world leadership and the political maneuvering which exists, no time can be lost in assuring the most effective results from the graduates of our technical schools, in the shortest possible time. Industry and our technical schools have a joint responsibility and if they will each cooperatively do their part, supported by the intellectual freedom, that exists in this country, we should have no fears for the future.

Sanitary Engineering Conference

A two-day conference on Sanitary Engineering Education sponsored by Committee 3 of the ASEE Civil Engineering Division, with the cooperation of the U. S. Public Health Service and the American Public Health Association, will be held at Dartmouth starting Saturday, June 21. The program of the conference is as follows:

Saturday, June 21

1:00 p.m.	Radiological Training
1:45	Field Training
3:15	Training Sanitary Engineers (panel discussion)

Sunday, June 22

9:30 a.m.	What is the Present Day Field of Sanitary Engineering?
10:30	Minimum Requirements for Sanitary Engineers
1:30 p.m.	Sanitary Engineering in the Smaller College
2:30	Graduate Program
4:00	Adjournment

Monday, June 23 Committee Reports

Arrangements for the conference are in charge of the following special committee:

Gilbert Dunstan, Chairman
Jess C. Dietz, Co-chairman
Arthur P. Miller
Ellis S. Tisdale
Earnest Boyce
E. S. Brown
William T. Ingram
E. J. Kilcawley

This committee is working in cooperation with Committee 3. Reservations for the conference should be made with Professor E. S. Brown of the Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire.

A Joint Attack on the Mathematics Entrance-Requirements Problem

By L. A. ROSE

Director of Engineering Information and Publications, University of Illinois

What is the biggest problem that plagues curriculum-makers? Manifestly the answer varies from one engineering college to another. But it's a safe bet that high on the list of "headaches" would be these three: What shall be the first required college course in mathematics? How much mathematical training can we expect of high school graduates? What guidance and help can we give to high schools so that we may receive students who have the preparation they need?

These are old problems everywhere, and everywhere they have become more pressing in the past few years. What we are doing at Illinois in an attempt to solve them will, we trust, prove interesting and indeed applicable beyond the borders of our own state.

Our Approach to the Problem

Three years ago we opened a broad attack on the problem. We began with the all-too-obvious fact that the engineering curriculum is badly crowded. In four years we can scarcely give students the fundamentals which they must have. Moreover, we must provide enough courses in the humanistic and social fields to encourage our students to become well-rounded individuals and effective citizens. Our problem, we felt, is to assure the fullest possible use of the time available for engineering courses without making our curricula narrow.

Now this brought us straight to the problem of mathematics requirements. In a sequential program such as engineering, a good deal of mathematics is needed as a prerequisite for physics, which in turn is the basis for most of the engineering courses. These truisms led us to experiment with requiring that the student take physics and certain engineering courses concurrently. The arrangement did not work. The only conclusion we could come to was that students expecting to graduate in four years should be ready for analytic geometry upon their admission to the College of Engineering.

The Solutions We Are Attempting

The conventional way to secure this aim is to require that students should present, for admission to the College, 2 units of high school algebra, 1 unit of plane geometry, ½ unit of solid geometry, and ½ unit of trigonometry. And we adopted this as one method, to go into effect in September 1953.

But we were unwilling to stop with such a solution. It was too rigid. It stressed means—academic machinery—rather than ends—skills and competencies. It would bear hard on students in smaller high schools. It would bear hard likewise on students in large high schools who may not choose an engineering career soon enough to take more than three years of high school mathematics.

The single-track solution would also be unfair to such high schools as are or will be experimenting with nonconventional division of the subject-matter of mathematics or with new teaching methods.

We did not want to hamstring those pioneers.

Consequently we carried our thinking further. In doing so we were guided by the Steelman report and other fairly recent national studies. We were also guided by a Bulletin of the Illinois State Department of Public Instruction, "New College Admission Requirements Recommended: A Proposal for Cooperative Action by the Secondary Schools and Colleges in Illinois" (No. 9, Circular Series A). We were encouraged and stimulated by the following passage in that publication:

> For specialized curricula, which begin in the freshman year in a college like engineering, certain specified competencies on the part of high school graduates may be required, such as competence in mathematics for engineering. For such cases the adoption of the following is recommended: "Secondary schools are urged to provide means for high school students to acquire prior to graduation the competencies demanded for successful work in specialized programs in institutions of higher learning, such competencies to be determined on the basis of standardized tests rather than on the basis of passing specified courses."

It's time to identify more fully this "we" I've been speaking of. "We" were not only the College of Engineering but also the College of Education and the Department of Mathematics. The three agencies worked through a joint committee which gathered data and views from many sources. These included not only the pertinent literature but a number of cooperating high school teachers whose aid was most valuable.

One of the biggest things the joint committee did was in part to anticipate and in part to follow up the recommendations in the Bulletin of the State Department of Public Instruction. Specifically, the committee prepared a list of the minimum mathematical needs of prospective students in the College of Engineering. This list comprises 97 topics in secondary mathematics, an understanding of which will enable the student to begin his college mathematics training with analytic geometry. The topics run from fundamental operations with integers, common fractions, decimals, and mixed numbers through trigonometric functions of an acute angle to addition and subtraction of vectors by components.

Thirty of the topics, which were identified by asterisks, are those normally studied in advanced (college) algebra and trigonometry. Students who have an understanding of all topics except those thirty will begin with college algebra and trigonometry as their first mathematics courses at the University These students will probably require an additional semester—that is, a total of four and a half years—to complete any one of our engineering curricula.

The committee drew up an additional list of thirteen topics recommended for study when time is available or by secondary school pupils of high ability. This list includes probability; the inverse, converse, and contra-positive of a statement; line values of trigonometric functions; and De Moivre's theorem.

The lists comprise about one-fifth of the material in a brief bulletin issued in October 1951. Its title is "Mathematical Needs of Prospective Students at the College of Engineering of the University of Illinois." More than 7000 copies of this publication have gone out to American high schools, and additional copies to engineering educators throughout the United States. Dean William L. Everitt and other administrators have orally set forth the gist of *Mathematical Needs* before groups of high school teachers.

To make the point still clearer, "*Mathematical Needs*" and our speakers offer rather detailed suggestions on counseling to high school classroom teachers and to high school advisors, many of whom know relatively little about the whats and whys of engineering-college entrance requirements and courses.

Ways of Meeting Our New Requirements

On recommendation of the joint committee, we went further yet. We specified

three ways other than by offering four units of high school mathematics in which students may fulfil the entrance requirements that will go into effect next year. These three ways (four ways, some people prefer to call them) are as follows:

1. By passing (a) a general proficiency examination in mathematics that covers the "indispensable skills"—the 97 topics—listed in *Mathematical Needs* or (b) proficiency examinations in the individual subjects which after September 1, 1953, will constitute the mathematics entrance requirements.

2. By passing correspondence courses. The University of Illinois Extension Division is offering, to students who have had 1 unit of algebra and 1 unit of plane geometry, the other mathematics courses needed for admission to the College of Engineering. Naturally, successful completion of correspondence courses offered by other accredited colleges and universities is equally acceptable.

3. By passing, at the University of Illinois, mathematics courses in which they are deficient. These may be taken in the summer session prior to the first full freshman semester. Some students may have to take an extra semester rather than merely the summer session; only a small percentage, we anticipate, will require an extra year.

We believe that—assuming proper guidance, aptitude, and ambition—the new admission requirements do not present undue difficulties for any high school student who wishes to be admitted to the College of Engineering of the University of Illinois. Although the new requirements call on some high schools to include more material in their mathematics courses, we believe that they permit and indeed encourage latitude in planning the high school mathematics program. High school teachers and officials have commended our cooperative approach to the problem, our concern for their difficulties as well as our own, and the variety of ways in which our new mathematics requirements can be met.

What Remains to be Done

But beliefs must be supported and praise lived up to. So we are developing the use of *Mathematical Needs* by cooperating in two additional joint committees with the College of Education and the Department of Mathematics. One committee is advisory to the experimental program in our University High School, incorporating these studies into an operating high school program. The other committee is studying the proficiency examinations which will be given to freshmen on entrance. We shall probably be issuing bulletins on the results of these studies.

In addition, we have been asking our fellow engineering educators to comment on our analysis of the problem, our approach to it, and our proposed solutions. This article itself is in part, then, an invitation to all interested readers of the Journal. We want your criticisms of what we have been trying to do. Copies of *Mathematical Needs* are still available, though in no large numbers. If you would like to read it and give us your reactions, we shall be glad to have them. The greater the exchange of information and views about this important curricular problem, the greater is the likelihood that we shall arrive at solutions which will best help the student to adjust to our own various situations and those of the secondary schools.

Report of The Student-Faculty Evaluation Committee

Introduction

The first report of the Student-Faculty Evaluation Committee was presented at the Annual Meeting of the ASEE, Seattle, Washington, June 22, 1950. It subsequently was published in the October 1950 issue of the *Journal of Engineering Education.*

Included in that report were a summary of the work of student-faculty evaluation programs up to that time and a discussion of the duties and responsibilities of students and teachers. The opinion was expressed that evaluation of faculty by students will probably continue in many schools. Further study of methods was recommended, with formulation of a suggested program for such evaluations.

The Need for Evaluation

It was stated in the 1950 report that the Student-Faculty Evaluation programs are not directed against any specific group of teachers. Rather, they are against the supposed general, unrecognized faults of most teachers. They indicate discontent on the part of many members of the student body; they indicate doubt as to whether the time, energy and money of the student is yielding him the return that he has the right to expect. The widespread development of evaluation programs in schools all over the nation probably constitutes a serious indictment of our collegiate education. Such an indictment cannot be shrugged off; it calls for careful study of the underlying causes of the discontent of which the programs are one manifestation.

Careful study of answers obtained in the evaulation programs shows that the principal offenses and shortcomings of which the teachers are accused are:

Lack of knowledge of subject;
Lack of fairness in grading;
Lack of interest in the student;
Etc.

Which of these are the fundamental causes of discontent and which are only symptoms? Your committee believes that, while individual teachers fail in fairness, in knowledge of their subject, in logical presentation, or in interest in the subject, the fundamental failures are not in these matters, but in the field of human relations.

Student-Teacher Relationships

The relation between the student and the teacher in the classroom is not a simple one. The student has no clear over-all picture of what each course should be; he has to take it for granted that the work assigned for each day is necessary. Still the student is basically the employer of the teacher. Unlike most employers, however, he lacks effective means of expressing his dissatisfaction with the service he is rendered.

The ideal classroom situation is one of give-and-take, wherein the student is free to question any statement and to express his opinions with complete confidence that his grade will not suffer because of such expression. Under this condition the students, being altogether human and somewhat immature, will frequently place themselves in untenable positions, as all of us now and then do, but that is an inevitable part of the seasoning that makes the person mature. Each slip of this kind is an opportunity for the teacher

to help his students to orient themselves personally and professionally. To waste these opportunities—to criticise the student who thinks erroneously, instead of helping him to correct himself—is to discourage and antagonize those who most merit help.

The autocrat of the classroom is a frequent object of complaint. Even if his teaching is technically excellent he still falls far short of his goal, for his autocratic attitude, his failure to permit students to function as thinking individuals, thwarts their development, no matter how sound may be the material that he presents. If he is autocratic because of the fear that the student may show up his incompetence, the student's situation is indeed sad. He has a valid cause for complaint, but dares not speak up because he feels that to do so will likely lower his grade.

The student-teacher relationship may be compared with that of the baseball player and his manager, or the automobile driver and the traffic cop. Human nature being what it is, there will inevitably be some teachers who, from their "superior" position, fail to accord to their "inferiors" the respect due a fellow human. The "superior" attitude will inevitably antagonize the students, setting up a block to the completely free play of ideas which is so essential to good teaching.

If practically all teachers were genuinely interested in the welfare of the students—if the teachers felt that the students were not entirely to blame if they learned little—if the teachers accorded the students due respect at all times and especially when they correct them, the Student-Faculty evaluations would never have started, regardless of how ineffective the teaching techniques were. The poor student seldom knows when the teaching is ineffective although he may think he does. The good student may recognize ineffective teaching, but he has enough self reliance that he does not mind. Virtually all students recognize and appreciate those teachers who are interested in their welfare; and they will forgive most teaching errors if the human interest is strong.

Proposed Evaluation Procedure

Your committee believes that some of the student-faculty evaluation programs that have been used in recent years are negative in both intent and effect, and that such programs will not continue long. We believe, however, that the student should have some means of expressing his views regarding the teacher and the course. He believe that the best way to accomplish this is as follows:

During the week prior to final examinations the student be handed a sheet of paper and an envelope. At the top of the sheet should be printed something like the following:

To the student:

Your teacher would appreciate having any comments you may wish to make regarding this course and his method of teaching. He particularly would like to know what you think could have been done that would have helped you to learn more.

After you have written your comments, place this sheet in the attached envelope and seal it. Write the teacher's name and the course number on the envelope and drop the envelope in the box provided in the department office. Your teacher will not pick up the envelopes until after the final grades are turned in to the registrar. These sheets will not be seen by the department head, but will be a great help to your teacher.

Check one:

(a)—This course is an elective

(b)—This course is required in my program

Your committee believes that comment regarding teaching is strictly a matter between the student and the teacher. If the department head or dean would like to know what the students think of the teach-

ers, another method should be used. The best method for this purpose depends upon the size of the school and the personalities involved. The department head who keeps in touch with his students and staff has no need of any artificial mechanism to tell him which teacher is doing a poor job, which one is technically proficient but is falling down in the realm of human relations, which one is outstandingly good.

Students should never be asked to vote for the one best teacher in the department. This method is wrong in more ways than there is room to list. However, it might be desirable several times during the semester, to pass out class cards for grading the teachers. On these cards the students write a letter grade, i.e. A B C D E for the teachers just as the teachers do for the students.

Conclusions

(1) Present methods, that is, methods involving check-sheet questionnaires for the evaluation of teachers by students are not suitable for a permanent "every semester" program. (2) Students should be asked for their written comments. (3) The formal student-teacher evaluation should be kept a confidential matter between the students and the individual teachers.

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Student-Faculty Evaluation Committee
FRED H. PUMPHREY, *Chairman*
Educational Methods Division

* * * *

Electrical Engineering Summer School

The Electrical Engineering Division will hold a Summer School at Dartmouth College on June 20 and 21, 1952. The theme will be "Undergraduate Teaching of Electrical Circuits and Fields." Registration will be $1.50. For further details address Dr. J. C. Ryder, Electrical Engineering Department, University of Illinois, Urbana, Illinois.

* * * *

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

THE T-SQUARE PAGE

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R. T. NORTHRUP
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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

B. L. WELLMAN, *Editor*
Worcester Polytechnic Institute

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The Squeeze Is On

By J. GERARDI
Assistant Dean of Engineering, University of Detroit

Industrialists and professional engineers like to face facts. Engineering educators are no exception; however, a doubt may be expressed at the willingness of either group to be realistic at times. Realism seems to be evaded and too often statements of facts are taken lightly when new courses are added to a curriculum and engineering drawing courses are all but eliminated.

Talk to a group of industrialists or engineers; as soon as they learn of your association with an engineering college, invariably the discussion will follow one of two paths. If the discussion concerns the profession, our industrial friends will tend to minimize specialization and concentrate their efforts on trying to persuade the educator to broaden the curriculum, emphasizing the fundamentals of design, and urging the educators to include a well-rounded program of studies in the field of Humanities. The objective, of course, is to produce men who are not only trained in a vocational sense, but men who have an intelligent understanding of the problems related to civic, social, and community life. This point is not argued. Industrialists as well as engineering educators are demanding that much more time be devoted to the development of the whole man. The need for training in the humanities has been recognized, and today a minimum of 20% of the student's curriculum is in this field. This is as it should be.

The changes to accommodate this new requirement did not happen over night. During the period of transition, courses in the humanities were offered in place of many technical frills. Educators revised and revised their syllabi and in all probability, were amazed to learn that the student still had time to master engineering fundamentals. It is a great source of satisfaction to know that their graduate can discuss matters pertaining to philosophy, literature, political science, etc. in a rational manner. Industry also has made it known that the graduate is a more versatile individual and that the numbers of engineers in sales, management, personnel, and executive positions are increasing at a magnificent rate.

Saturation Point

However, since both the sciences and the arts are fields which constantly develop and expand, a saturation point has been reached. Technical subjects which had been cut to the bone must be expanded because of new developments which in themselves are highly fundamental; hence, directors of degree-granting departments can no longer be expected to reduce the

amount of time devoted to technical studies.

No professional engineering drawing teacher in his right mind would oppose a reasonable concentration of course content or a reasonable reduction in the time element necessary to teach drawing if as a result of his contribution, the status of the engineering graduate is improved. But it was never intended to eliminate drawing courses from the engineering curricula. Certainly no one could classify these courses as frills, nor is it conceivable that in the near future an electronic device will be produced which will record the ideas in the minds of engineers and transmit them to other people. Moreover, the Engineering Council for Professional Development has not even implied that drawing is to become a requirement for admission to an engineering school. Yet, a few well-known colleges in this country have eliminated drawing from their curricula and several schools now require their students to take only one course in technical sketching.

Employer Viewpoint

But let's talk to the men who employ engineering graduates. Here the conversation takes on a different aspect. The chief engineer or chief draftsman is proud of the fact that graduates are the finest men (in every sense of the word) he has ever employed. Their knowledge of mathematics, theory of stresses, history, economics, etc. are much more improved over that of the graduate of fifteen years ago; but they ask, "Who gave the graduate the idea that he would have several draftsmen at his call? Even if a graduate has draftsmen working for him, what respect can the draftsmen have for the graduate, or the school from which he graduated, if the young engineer does not know how to prepare a preliminary design drawing from which the draftsman can proceed with layouts and detail drawings?"

Hence, those responsible for teaching drawing courses find themselves caught between the "Devil and the deep blue sea." Pressure from educators and industrialists demanding men, who in addition to their technical training, are prepared to assume leadership in the field of human relations as well as the responsibilities which are imposed on professional people in a complex society. Pressure from the immediate supervisor of the neophyte who is more interested in meeting production schedules than in the "development of the whole man."

But let's be realistic. The issue is whether or not Engineering Drawing is essential to an engineer's education. Either it is or it is not. If so, then it deserves sufficient time and qualified personnel to do a good job of teaching the true fundamentals of drawing; if not, then let us eliminate drawing courses from the curricula, rather than give such meager courses which at best result in embarrassment for the young engineer and loss of prestige for the institution from which he graduated.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College Hanover, N.H.

Candid Comments

Statement of Carey H. Brown, Chairman, Engineering Manpower Commission of Engineers' Joint Council, Before the Committee on Armed Services, U.S. Senate on February 11, 1952 in Connection with S-2441

The following statement, of interest to members of ASEE, was made by Mr. Carey H. Brown, Chairman, Engineering Manpower Commission of the Engineers' Joint Council, before the Committee on Armed Services, U. S. Senate on February 11, 1952 in connection with Bill S–2441.

The interest of the Engineering Manpower Commission is in the training, allocation, and utilization of engineers to insure their maximum contribution to the national defense and to the national health, safety, and interest.

The Engineering Manpower Commission recognizes that in an all-out war there will be no Zone of the Interior and that civilians will be subjected to many if not all of the hazards to which members of the armed forces are subjected.

The Engineering Manpower Commission therefore emphasizes the principle that there is a universal obligation upon every man and woman for appropriate service of which each is capable in maintaining the security of the United States.

It is further recognized that as a people we have less manpower than our potential enemies and that it is therefore of fundamental importance that each person be utilized at his highest capability. In view of the wide range of talent and training necessary to adequately staff our civilian economy, military operations, and production, the wisest system of selection is necessary.

It is further recognized that maintenance of a sound economy and of the required production of weapons are both essential if the man at the front is to be effective, and that these are part of an inseparable whole in maintaining the security of our Nation.

In connection with current proposals for the activation of universal military training, it is imperative that the above principle be applied.

The Engineering Manpower Commission favors Universal Military Training, observing, however, that the provisions of P.L. 51, S.2441 and H.R. 5426 do not adequately make provision for maximum utilization of those who complete their training and enter reserve status.

It is therefore important that the following pertinent principles be established now and incorporated in S. 2441:

(a) Upon completion of their six months training under UMT, the recall to active duty from reserve status of the required number of professional and scientific students should be held in abeyance until completion of their professional study or until they cease to satisfactorily pursue such study. Speaking only for the engineering profession, there is a current requirement for 60,000 freshmen each year in all branches of engineering to meet the need for engineers in the armed forces, in design, development, and production of military equipment, and in the civilian economy.

As a suitable method of accomplishing the above, we suggest the following amendment:

"Amend existing paragraph (3) subsection (D) section 4 of the Universal Military Training and Service Act, as amended (P.L. 51—82nd Congress) by inserting at the end thereof the following: 'Provided, however, that any person who is satisfactorily pursuing a full-time engineering or scientific course of instruction at a college, university, or similar institution of learning shall have his recall to active duty delayed (a) until the time of his graduation therefrom, or (b) until he ceases satisfactorily to pursue such course of instruction, whichever is earlier.

" 'Provided, further, that the total period of liability for training and service of a person so delayed shall be extended by the period of such delay.' "

(b) Since the principle of selection must be applied in connection with the recall of reservists to active duty to assure the proper allocation of critical skills between the civilan economy and the armed forces, reservists should be called to active duty only by a civilian agency such as Selective Service, and not by the Armed Forces.

The civilian agency of Selective Service has functioned in the past to make selections for military service and for the necessary economy; such selections being based upon considerations of meeting military requirements and at the same time preserving essential production facilities. Selective Service can readily be adapted to carry out the selections advocated above, so that appropriate determinations can be made to promote the best utilization in the national interest of professional and scientific personnel now in short supply.

As a suitable method of accomplishing this, we suggest the following amendment:

"Whenever it becomes necessary to recall reservists to extended active duty involuntarily, such individuals shall be recalled by the Selective Service System under uniform regulations to be prescribed by the President and all provisions of the Universal Military Training and Service Act, as amended, concerning classification shall be applicable to the recall or delay in recall of such individuals by the Selective Service System."

I would like to thank the chairman and the members of the Committee for the opportunity to appear in connection with the hearings on S–2441.

TIMELY TIPS

The Direct Approach to Deflections and Intermediancies in Bending

By RALPH H. UPSON
Professor of Aeronautical Engineering, University of Minnesota

(Papers submitted for TIMELY TIPS should not exceed 3 pages of typewritten double-spaced material, including any mathematical formulas, and should contain not more than 2 illustrations.)

In his "Timely Tips" article in the October issue, Professor Jackson performed a much needed service in pointing out the need for a return to basic principles in the undergraduate teaching of beam deflections. Fancy methods and specialized shortcuts may be great fun for the teacher and are often justified for engineering specialists, but have no place in an undergraduate curriculum. In this fast growing field of constantly increasing complexity, we must occasionally review the content of our courses, discard the gingerbread, and go back to basic elements, the real staff of engineering life.

Although in the right direction, it is felt that Professor Jackson does not go far enough in the simplification or generalization of his subject. For some years we have used in aircraft structural courses at the University of Minnesota a method that we call the Direct Approach, along lines closely analogous to Professor Jackson's, but which is still more elementary and universal in its application. Emphasis is particularly put on the angular deflection of an infinitesimal beam element which forms the basis of the entire procedure. Such an element is shown in Fig. 1 (corresponding to Professor Jackson's Fig. 2).

Referring to Fig. 1, it will be noted that the change in angle $d\theta$ at the opposite ends of the increment dx is the usual direct function of the local bending moment of the beam, the section moment of inertia, and the modulus of elasticity of the material. The vertical deflection which this angular change causes at some other point B, a distance of Δx_B is:

$$dy_B = \Delta x_B d\theta = \frac{\Delta x_B dx}{R} = \frac{\Delta x_B M dx}{EI}. \quad (1)$$

Our further development of the method proceeds directly from the integration of angular increments $d\theta$ and deflection increments dy. For example, Fig. 2 shows a portion AB of a deflected beam—no matter where taken, how loaded or supported. The difference in angle (assumed small) between the tangents at points A and B is given by

$$\theta_{AB} = \int_B^A d\theta. \quad (2)$$

The deflection or vertical offset of point B relative to the tangent at A is similarly given by the integration:

$$y_{BA} = \int_B^A \Delta x_B d\theta. \quad (3)$$

Relative to the chord line AB, the actual angle of the tangent at A is obviously

$$\frac{y_{BA}}{x_{AB}} = \frac{1}{x_{AB}} \int_B^A \Delta x_B d\theta. \quad (4)$$

Knowledge of the latter as a starting point now permits integration of the

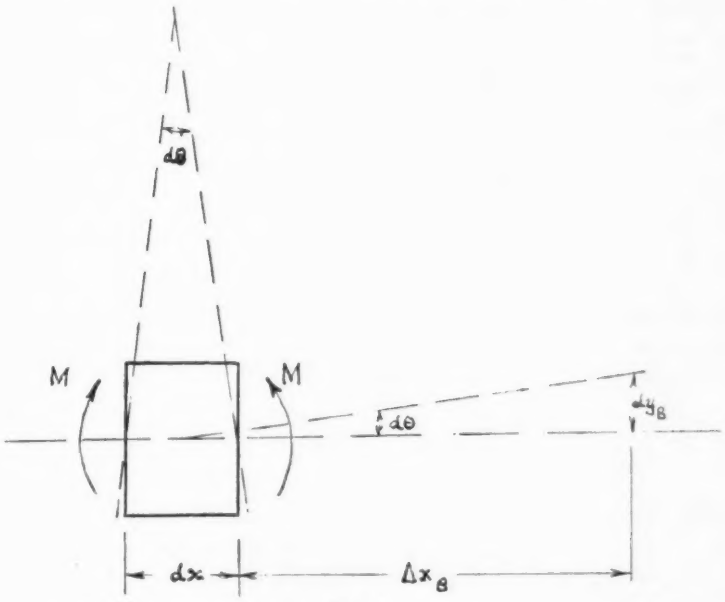

FIG. 1.

angular change and linear deflection at any other desired point, by exactly the same method as already illustrated in the case of point *B*. It is apparent that such integration need not necessarily be mathematical, but may alternatively be performed graphically, equivalent to the moment-area method.

For statically indeterminate conditions, exactly the same principles apply, it being only necessary to supplement the conditions of static balance by equations expressing the deflection conditions, to provide a solution. For example, a cantilever beam, with a simple support in addition, gives the condition of a

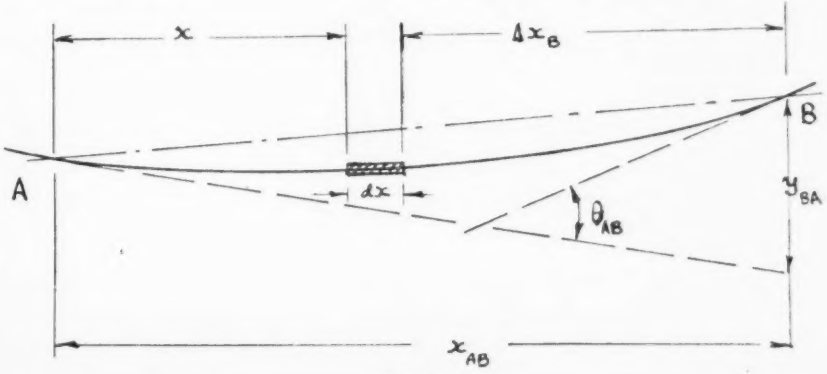

FIG. 2.

known angle at the fixed support and a known position at the simple support. For a continuous beam with multiple simple supports, the supplementary condition is that the deflection angle is the same immediately to each side of any one support.

Essentially the same method can be extended to the solution of slender curved beams and closed frames, the condition for the latter being that an integration all the way around gives zero angular change and zero linear deflection. The deflection in the general case is handled in components in any two convenient mutually perpendicular directions, the x movement being controlled by the y arm and vice versa, exactly as in the beam case already given. A convenient aid in visualizing the case of an initially curved member is to think of each infinitesimal element of length ds as initially straight.

It is admitted that this approach does not provide a ready-made formula or method, convenient to pick up and use for a specific purpose, such as the three-moment equation or the unit-load method, but it is far more adaptable and should provide a more understanding grasp of whatever specialized methods the student may later choose to use.

English Division Summer School

Theme: Orienting the New English Teacher in the Engineering School.

Session I, June 20, 9:00 A.M. Topic: The English Teacher in the Engineering School.

Session II, June 20, 2:00 P.M. Topic: Has Freshman Composition Failed?

Session III, June 21, 9:00. A.M. Topic: Standards of Correctness: Prescriptive vs. Descriptive Grammar.

Session IV, June 21, 2:00 P.M. Topic: Articulation of High-School and College English.

Session V, June 22, 2:00 P.M. Topic: What Literature to Teach and How to Teach It.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State College	April 18–19, 1952	E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Villanova College	May 10, 1952	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oneken, Jr., Bureau of Ordnance
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Washington	April 25–26, 1952	T. H. Campbell, University of Washington
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	S. F. Duncan, University of Southern California
Rocky Mountain	University of Wyoming	April 19, 1952	E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 25 & 26, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

BIRNIE, CLOTWORTHY, JR., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. E. P. Nye, N. R. Sparks.

BOWDEN, FREDERICK W., Instructor and Head, Department of Electrical Engineering, California State Polytechnic College, San Luis Obispo, Calif. C. E. Knott, N. Sharpe.

BRYANT, JOHN, President, The Pitman Publishing Corporation, 2 West 45th Street, New York 36, N. Y. A. B. Bronwell, S. C. Hollister.

CANJAR, LAWRENCE N., Assistant Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. J. W. Graham, Jr., C. C. Monrad.

CASPARY, GERALD J., Assistant Professor of Civil Engineering, Michigan College of M. & T., Houghton, Mich. E. P. Wiedenhoefer, W. C. Polkinghorne.

COOMBS, LESLIE B., President, Bradford Durfee Technical Institute, Fall River, Mass. R. B. Finch, G. N. Reed.

DiILIO, CHARLES C., Associate Professor of Mechanical Engineering, Pennsylvania State College, State College, Pa. N. R. Sparks, E. E. Ambrosius.

FAIGENBAUM, HAROLD M., Professor of Inorganic Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y. A. A. K. Booth, P. E. Hemke.

FERNANDES, JOHN H., Instructor in Mechanical Engineering, Lafayette College, Easton, Pa. T. R. Blakeslee, K. D. Larsen.

FOX, RICHARD B., Associate Professor of Architectural Engineering, Pennsylvania State College, State College, Pa. B. A. Whisler, L. Perez.

FUHRIMAN, DEAN K., Associate Professor of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo. H. H. Schweizer, H. W. Collins.

FUKUDA, TAKEO, Professor of Civil Engineering, Institute of Industrial Science, University of Tokyo, Chiba City, Japan. H. L. Hazen, A. B. Bronwell.

GERING, GEORGE K., Employment Supervisor, West Penn Power Company, Pittsburgh, Pa. A. B. Bronwell, S. C. Hollister.

GRAVES, WILLIAM A., Instructor in Mechanical Engineering, Colorado A. & M. College, Fort Collins, Colo. H. B. Mummert, H. H. Schweizer.

GUPTA, SAT BRAT, Mechanical Engineer, Central Tractor Organization, New Pusa, New Delhi, India. P. H. Kyburz, C. C. Sigerfoos.

HANCE, LACONLA H., Research Associate in Textile Engineering, Institute of Textile Technology, Charlottesville, Va. R. B. Finch, G. N. Reed.

HOFFMAN, EUGENE F., President, Fournier Institute of Technology, Lemont, Ill. R. E. Bard, A. B. Bronwell.

HOLDHUSEN, JAMES S., Research Fellow, Civil Engineering, University of Minnesota, Minneapolis, Minn. T. W. Thomas, G. J. Schroepfer.

HORNUNG, WILLIAM J., Director of Training, National Technical Institute, 214 West 23rd Street, New York 11, N. Y. W. J. Luzadder, J. E. Pasek.

IRLAND, MAX J., Associate Professor of Electrical Engineering, Detroit Institute of Technology, Detroit, Mich. L. L. Henry, C. C. Winn.

JONES, ROBERT R., Instructor in Metallurgical Engineering, Lafayette College, Easton, Pa. W. B. Plank, E. L. McMillen.

KESLER, CLYDE E., Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. W. L. Collins, W. M. Lansford.

KLEINSCHMIDT, ARTHUR C., Assistant Professor of General Engineering, Iowa State College, Ames, Iowa. J. P. McKean, J. P. Mills.

KNIGHT, WILLIAM C., Temporary Head, Textile Engineering, Alabama Polytechnic Institute, Auburn, Ala. R. B. Finch, G. N. Reed.

LI, CHENG CHING, Special Lecturer, Engineering Drawing, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland, A. Wardell.

MACKICHAN, KEITH B., Head, Electrical Engineering Dept., University of North Dakota, Grand Forks, N. D. E. L. Lium, M. H. Chetrick.

MINARD, GEORGE W., Associate Professor of Chemical Engineering, Bucknell University, Lewisburg, Pa. H. D. Sims, W. D. Garman.

NEWTON, HEBOR T., Instructor in Civil Engineering, Pennsylvania State College, State College, Pa. B. A. Whisler, L. Perez.

PIAN, RICHARD H. J., Assistant Professor of Civil Engineering, Michigan State College, East Lansing, Mich. L. V. Nothstine, C. L. Shermer.

RADIUS, CLARENCE, Head, Electrical Engineering, California State Polytechnic College, San Luis Obispo, Calif. C. E. Knott, N. Sharpe.

SAUTER, HUBERT E., Engineering Librarian, The Library, Oregon State College, Corvallis, Ore. G. W. Gleeson, F. O. McMillan.

SCHEIRER, ROBERT D., Associate Professor of Civil Engineering, Pennsylvania State College, State College, Pa. B. A. Whisler, L. Perez.

SCHILLER, DANIEL E., Instructor in Engineering, Marquette University, Milwaukee, Wis. W. D. Bliss, R. L. Ritter.

SCOTT, SAMUEL L., Personnel Interviewer, E. I. duPont de Nemours & Co., Inc., Wilmington, Dela. D. W. Durham, G. O. Andrews.

SHAFFER, WILLIAM R., Assistant Professor of Engineering Mechanics, Pennsylvania State College, State College, Pa. J. W. Breneman, L. Perez.

SHELDON, EVERETT L., Deputy Chief, Industrial Mobilization Planning Section, USAAF, Detroit, Mich. F. L. Partlo, C. F. Duggan.

SHULITS, SAMUEL, Associate Professor of Civil Engineering, Michigan College of M. & T., Houghton, Mich. W. C. Polkinghorne, E. P. Wiedenhoefer.

SIDEBOTTOM, OMAR M., Assistant Professor of Mechanics, University of Illinois, Urbana, Ill. W. L. Collins, H. T. Carter.

SLONAKER, ROBERT E., Jr., Instructor in Chemical Engineering, Bucknell University, Lewisburg, Pa. H. D. Sims, W. D. Garman.

STARKEY, WALTER L., Assistant Professor of Mechanical Engineering, Ohio State University, Columbus, Ohio. D. J. Masson, S. M. Marco.

STINSON, WILLIAM G., Lecturer, Engineering Drawing, University of Toronto, Toronto, Ont., Canada. L. S. Lauchland, W. J. T. Wright.

TANNER, DONALD L., Instructor in Civil Engineering, Pennsylvania State College, State College, Pa. B. A. Whisler, L. Perez.

WITMER, LUTHER F., Associate Professor of Min. and Met. Engineering, Lafayette College, Easton, Pa. G. W. Courtney, Jr., E. L. McMillen.

WOLF, HARRY K., Associate Professor of Electronics and Radio Engineering, California State Polytechnic College, San Obispo, Calif. N. Sharpe, C. E. Knott.

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College Notes

The Department of Civil Engineering at **The State College of Washington** has available four positions as Research Assistant for students desiring to work toward the degree of Master of Science in Sanitary Engineering. These positions will involve half-time service during the academic year at a stipend of $1200 for the nine and one-half month period. Full time positions will be available during the summer months at a salary of $250 per month.

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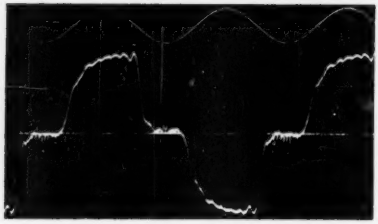

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GENERAL ELECTRIC

Social and Political Forces Affecting Civil Engineering Education*

By N. A. CHRISTENSEN

Professor and Director, School of Civil Engineering, Cornell University

The American desire to preserve our way of life in a world which is becoming overpopulated and stimultaneously compressed by more rapid means of communication is the basic cause of social and political stress in the United States. The United States is strong but the opponent which threatens her is the most powerful enemy our country has ever faced. In a larger sense the conflict is between democratic and communistic ideas. The United States and Russia are simply the leaders of the opposing groups of nations. Peoples of the whole earth are trying to decide which is the best political system—democracy or communism. Many nations have already chosen sides and those which have not are torn with internal turmoil in trying to make a decision.

This great conflict coming at a time when some parts of the earth are overpopulated magnifies the importance of the ultimate outcome. In many of the more densely populated sections it is no longer possible to provide adequate food, clothing, and shelter by means of the native agricultural and manufacturing procedures. Such areas of world population look with envy upon the abundance of everything enjoyed in the United States. If such areas can be helped toward our level of living, they will follow our pattern. If not, they will join hands with the enemy and try to pull us down.

* Presented before the Educational Policy Section of the Civil Engineering Division ASEE, Annual Meeting, Michigan State College, June 1951.

Our Task as a Nation

What then is our general task as a nation? There seems to be no other course than to follow our government's proposals to help other people to solve their problems but at the same time keep our nation strong enough to beat down any group which wants to shape the future by force of arms. Civil engineering education has an important role in this world drama. Both foreign and American civil engineers must be trained to have the breadth of social knowledge and technical excellence to transfer American know-how in civil engineering to underdeveloped countries. This must be done in a period much shorter than the 150 years of our own industrial evolution, and without causing serious social and economic maladjustment among the peoples of the earth.

Engineering leaders are needed who are also good economists, others who are also good sociologists, and others who are also good statesmen. Too few of our Civil Engineering graduates have a broad enough foundation to support a career in important international relations requiring extensive knowledge and training in these subjects. In fact not many engineering schools have faculties completely competent to impart such an educational foundation to students. The 20 per cent of humanistic studies so widely accepted is only a start toward what is needed. Some of our best students and staff members should pursue graduate study and aim at engineering statesmanship as a goal.

Need for Specialists

For this world wide job of regional development we also need more specialists with great depth of knowledge in certain fields. Men who can locate the mineral, land, and water resources, others who can plan extensive transportation systems, others who know how to plan, build, and expand cities and still keep them safe against traffic accidents and disease. Other are needed to irrigate the deserts, others who know about flood protection, others who can wring out the last useless pound of dead weight from structures and so on. Graduate study at a university seems to be the most economical way to provide these specialists. After our graduates leave college most of them continue to grow but this growth in most cases is limited by the strength of the mathematical and scientific foundation which they received in college. It is not so difficult for engineers to keep abreast in fields which do not require high ability in the application of mathematics but even in such fields the schools are important centers for improvement and advancement at accelerated rates. It should also be pointed out that in nearly all engineering fields, advances soon carry us into considerations involving mathematics, physics, or chemistry. The civil engineering schools, associated with their respective universities, can provide the best environment for these urgently needed research advances. We have the long-haired scientists and also bright eager young men. Both are needed in our research teams. The civil engineering schools should push vigorously forward on research and graduate work in order to increase the number of top quality engineering scientists which our foreign program and national security demand.

Our output of engineering graduates will be about 15,000 per year for the next several years and at the present rate about 10 per cent of these men pursue graduate work. When one compares this output to the estimated 30,000 engineers per year produced by Russia with a level of training equal to the M.S. degree, the need for maximum utilization of our manpower is emphasized. If we have only one to every two of the enemy our techniques and methods will have to be enough better to magnify our efforts by two. More research will certainly be needed in order to offset quantity with quality.

So far our attention has been focused upon the need for engineers who can serve in an international capacity. The foreign students trained here will supply part of this need but some of our American-born graduates will also be required. By far the biggest demand for American-born graduates will be in the U. S. itself. During the entire struggle between the democratic and communistic systems for world leadership, the United States must remain so strong as to discourage conquest by force of arms. If such a conquest should be attempted we will have to be able to subdue the aggressor.

The work of civil engineers provides the environment for the nation's people. Structures, roads, factories, homes, cities, water supplies, sewer systems, irrigation projects, regulated rivers, and parks are some of our products. The life and comfort of the people at large are in our hands. Our work if well done will increase our national efficiency. If there was ever a time when national efficiency was needed, it is now. We are now short of engineers and to do our job within the United States we need many more graduates.

Our Duties as Administrators

What then are our specific duties in the near future as administrators of civil engineering schools? The following are given as suggestions for discussion:

1. Do all in our power to keep the flow of engineers coming. Do not let our extra efforts disrupt going school organizations. Try to increase the number of freshmen admitted and try to keep sufficient staff members to maintain our schools in healthy condition.

2. Take every opportunity to expand the training and experience of our staff.

Civil engineering education has become somewhat traditional and the pace of our advance needs acceleration if we are to produce the engineering statesmen and engineering scientists called for by our times. To meet this need a substantial improvement in staff quality is needed.

3. Shift our outlook from a national basis to a worldwide basis. We are not building empires but new frontiers have opened in every underdeveloped country. The development of deserts, jungles, and natural resources for a rapidly expanding world population has added many new geographical frontiers.

4. Push forward in graduate work and research. Each school should survey its opportunities for advanced work. Do not be too frightened of false starts. The good old law of supply and demand will eliminate such starts after a fair trial. We do nothing unless we risk a start. Do not be too discouraged by a few failures. The process of trial and error is at the roots of all that makes America great.

5. In short, our future job is to prepare for the tasks of world leadership which events of the immediate past have thrust upon us. The intensiveness of the present "battle for men's minds" will not permit a leisurely preparation. There is no time to be wasted.

In the News

The Fourth Annual Oak Ridge Summer Symposium, scheduled for August 25–29, 1952, will be sub-titled "The Role of Atomic Energy in Agricultural Research."

As contemplated, a number of sessions will be devoted to plant and animal studies with atomic energy research tools. Other lectures will deal specifically with Carbon-14 studies in both plants and animals.

The symposium is being given by the Oak Ridge Institute of Nuclear Studies and the Oak Ridge National Laboratory under the sponsorship of the University of Tennessee-Atomic Energy Commission Agricultural Research Program.

Additional information may be obtained from the University Relations Division of the Institute, P. O. Box 117, Oak Ridge, Tenn.

Dr. Raymond John Seeger, formerly Chief of the Aeroballistics Research Department of Ordnance Laboratory at White Oak Maryland, has been appointed to the staff of the Division of Mathematical, Physical and Engineering Sciences of the **National Science Foundation.**

The Future Prospects of Improved Preparation for College

By C. E. MacDONALD

Superintendent, East Lansing Public Schools, E. Lansing, Mich.

Proper guidance in high school, and even in earlier years, can have a great deal to do with the high school preparation of prospective engineering students. I am happy that we are thinking of this as a guidance process rather than one of selection. The objective is not the elimination of the unfit. The objective is to guide into the engineering field those who belong there because of ability to absorb and make use of certain types of information; because they possess the necessary personal qualities; and because, above all else, they have a very real interest in the engineering profession.

We must be very careful about ruling out prospective engineers, particularly on the basis of subject grades or standardized test results. Technical competence is surely required of the engineer, but let us not be too certain that high academic grades and high test scores assure technical competence in the engineer. On the other hand, let us be equally careful concerning low academic grades and low testing scores. They do not always mean low ability.

I recently came across an article written by Harvey Zorbaugh, Director, Counseling Center for Gifted Children, New York University, in which he points out the dangers inherent in the belief that we can spot people of promise while they are still in school by their grades and their scores on I.Q. or aptitude tests. He feels that there is real danger in the extent to which this belief is being accepted in our national life.

Experience points out that many individuals possess, or later develop, other talents and qualities, such as ambition, drive, leadership, character, and the faculty of working well with other people, which cause them to be outstandingly successful. Henry Ford II failed in his Yale engineering course. Subsequent events proved this to indicate a lack of interest at that time, rather than a lack of ability. Charles E. Wilson of General Electric never finished high school. One could cite such cases almost endlessly.

Several great dangers exist in using grades and test scores as the primary basis to be used in guiding high school youth into the field of engineering:

1. Low grades may indicate lack of interest rather than lack of ability.
2. Poor teaching and low motivation can acount for lack of interest.
3. Outside factors can affect examination and test scores.
4. High academic ability does not of itself assure success in the engineering field.
5. Many gifted men have shown little indication of their ability in school.

Guidance Program

No doubt I am taking too much time to say things which have already been said. But what I have said about guidance indicates a great deal for our high school preparatory program. One might say that there are three vital parts of a program. They are:

1. Guiding young people. This involves use of all available data; and creating an interest on the part of qualified students.

2. The program itself. What are the objectives of the program? What are the possibilities in each individual school's program?
3. The program in operation. Is it well carried out? How may performance be improved?

A high school guidance program for prospective engineers has been very ably presented. My concern is that we use a broad basis in guiding students into engineering; that we be very reluctant to say, "You are not qualified."

I hope, also, that we have a broad point of view concerning our preparatory program. Nobody thinks more highly of technical competence than I. There is no question in my mind concerning the need for mastery of the subject matter of the field. One must have tools with which to work.

Individual schools will vary greatly concerning the extent of the information they are competent to handle. Teachers vary in knowledge and ability. Schools vary in scope of instructional materials. People responsible for planning vary in vision. The small school is likely to be at a disadvantage in regard to courses that can be offered.

This is indicated in a recent publication of the Bureau of School Services, University of Michigan. It is entitled "Program of Studies of 176 Michigan North Central Secondary Schools."

Variations in Science Units

Let us look at the science units offered in these schools. Three and four are average. I presume that this means Biology, Physics, and Chemistry, and General Science, in addition, when four units are offered. However, we find approved schools offering but one or two units in science. At the other end of the scale, we find schools offering as high as eight units. We can readily observe the great variation in the amount of information offered.

Strangely enough, there is considerable variation even in schools of comparable size serving the same types of areas.

In the field of mathematics, the same story is told. Just considering our high schools with over one thousand enrollment, we find a range of from three to ten units in mathematics offered. A number of the small high schools offer as few as two units in the field of mathematics, presumably algebra and geometry.

It seems obvious that many high schools might well give attention to basic offerings in science and mathematics. But the road is not easy. Our state department of public instruction has long advocated consolidation of small school districts, so that richer school programs might be offered. More financial resources would enable a district to provide necessary facilities, and to pay the necessary salaries to attract competent instructors.

But take the large high school backed by a well-to-do school district. How explain the meager offerings sometimes found in these schools? Obviously the students are not asking for extensive preparation in science and mathematics, the fields we are considering. Why? Very likely because they see no need for them. Possibly a strong guidance program could awaken them to the great possibilities they are overlooking. Doubtless many strong prospective engineers are being overlooked. Also, students are probably avoiding these courses because of the way they are being taught. If the procedure is to assign the learning of facts and information, unrelated to any vital student concern, it is not surprising that they stay away in droves. I shall have more to say later about the effectiveness of our teaching.

Mastery of Fundamentals Necessary

My conclusion would be that all schools should concentrate on mastery of the fundamental principles of mathematics and science in the high school years, and then offer such advanced courses in the field as facilities permit. At least one over-all unit concerning itself with the

various engineering fields might well be offered.

We want professional competence in our engineers. Certainly we all agree. But what else? General Somervell says that the second thing that the engineer must be able to do is to "take his place in the organization that he joins." He must be able to get along with other people. If he is to go very far in his chosen profession, he must also be able to handle people. I doubt that many of our high schools have spent sufficient thought on ways of preparing engineers to develop, or helping them to develop, this greatly needed ability. I suspect that many engineering schools have done less.

The engineer must understand the economies of our life. He must be acquainted with general principles of Business Administration. In most high schools this probably means the course in economics as preparation for further courses.

Engineers do not live in a vacuum. They need common abilities that we try to develop to the extent of each individual's abilities. Engineers need to be competent in communication skills. They, as much as any, need to know our history and traditions. Engineers require some cultural background if they are to live fully. Engineers share the responsibility of all to play some part in improving their community, their state, their nation, their world.

Since these are common skills, the high school seeks to prepare all in regard to them. But let us not fail to see them as necessities in preparing the engineer, among the others.

There is, assuredly, plenty of room for improvement in our high school programs for preparing prospective engineers. We must, first, give the student all the personal development possible. This is true in the cases of all of our students. The schools exist primarily to do their utmost to prepare people for living, for citizenship—whether it be as engineers, doctors, lawyers, writers, farmers, secretaries, laborers, or housewives. It is the schools' second function to guide young people into a suitable life work, and to do all possible to prepare them for that life work.

Hope for Advancement

One of the greatest hopes for advancement in the content of our preparatory course lies in the ability of high schools and professional schools to get together in planning the objectives and developing the material for the courses.

In Michigan our College Agreement Plan has found a means of high school and university and college coming together to plan for the common good of the student. It has already resulted in changes in high school programs. I even know instances where it has resulted in program changing on the higher levels of education.

Perhaps the greatest future prospects of improved preparation for college are contained in the third step I mentioned. That is, the actual operation of the instructional program of the high school. We can reach agreement on the objectives of our guidance program and how it is to function. We can, possibly, reach agreement on the objectives of our preparatory program and how it should be set up.

But when it comes to operating these programs, we are dependent upon teaching. The best of programs will be ineffective in some hands. Basically, the improvement in preparatory courses must come through improved instruction.

The first step in good instruction is to arouse interest. Students do not learn and retain knowledge without motivation. If we content ourselves with motivating students by telling them that they must absorb such and such information to become good engineers, we shall make no progress toward improving our preparatory courses. If, on the other hand, we use the problem-solving technique in teaching, we shall draw the students into a challenging situation. They will be interested because they have a part in defining the problem; suggesting solutions; examining the suggestions by means of the

subject matter of the field; and in further observation and experiment leading to acceptance or rejection of the solution. In short, we must make our preparation much more realistic.

I suppose what I have just outlined constitutes the "engineering method." What I am saying is that we should use this teaching approach to interest our students in the subject matter, and to discover the students capable of using the engineering approach to problems.

In my opinion, our preparatory programs for engineering students are weak in that we stress the acquiring of subject matter above the development of the ability to attack problems in a logical manner. We confuse the ability to read, to listen and retain, with the ability to think. Subject matter may always be looked up. There is no place to turn to look up information that may be substituted for the lack of ability to attack a problem.

Abandon subject matter? Of course not. But let us make use of it to stimulate the imagination of our prospective engineers; to arouse their curiosity; and to develop their analytical ability. And let us not forget that the engineer needs to develop common qualities essential to successful living for any of us.

I sincerely believe that we can improve our high school preparatory courses through:

1. Better guidance practices.
2. Improved offerings concerning the subject matter of the field.
3. Setting up as our objective the developing of imagination, curiosity, and logical thinking processes. Using the subject matter as a means of attaining these ends.

This will call for improved facilities and improved teaching. As a school administrator, I regard it as my responsibility to try to create a school situation, a school atmosphere, in which these things can happen.

College Notes

A three-day Conference on Soil Stabilization will be held at the **Massachusetts Institute of Technology** from June 18 to June 20 to examine current problems in stabilization treatment.

Baldwin-Lima-Hamilton Corporation has completed installation of a 600,000-lb. testing machine in the new Structures Laboratory for Civil Engineering and Engineering Mechanics at **Purdue University.** It is a part of a modernization project that will ultimately cost about $3,500,000.

A special program in Infrared Spectroscopy will be given from June 16 to June 27 during the 1952 Summer Session at the **Massachusetts Institute of Technology.**

George F. Carrier has been named Gordon McKay Professor of Mechanical Engineering in **Harvard University.** He is now at Brown University, where his work has been in applied mechanics, especially in fundamental problems in elasticity and fluid mechanics.

Economics and Engineering Economy

Their Relationships and Their Value to Engineers*

By BILLY E. GOETZ †

Professor of Business Administration, Antioch College

Eleven years ago I spoke to the Engineering Economy Section on the use of economic logic by engineers confronted with problems of engineering economy.‡ Today I want to discuss some broad areas of greatly increased importance in which economics can contribute data as well as logic to the engineer's attack on such problems.

Many, if not nearly all, of managements' problems of policy formulation, of choice of resources, of product design, of organizational planning, and of selection of methods and procedures can be subsumed under the classic question of engineering economy—will it pay? In approaching such problems today, the manager and the engineer find the factors to be considered so changed in content and in relative importance as to make his world rather new, strange, and somewhat forbidding. Most of these new, or newly important, factors have arisen within the areas studied by economists. Consequently, economics has a new and somewhat different contribution to make to engineers and managers struggling with "will it pay" problems. Since nothing is really new, we will find that some of these factors have been around a long time, but recognition of their importance has been delayed, and they have not yet been adequately worked into the literature of engineering economy.

How will creeping (or is it faster than that?) inflation affect the relative desirabilities of alternate programs? How do taxes, present and prospective, affect choices among rival plans? How do governmental regulations, current and anticipated, change the terms of engineering economy problems? These questions are conspicuous by their absence in the literature of engineering economy, and by their omnipresence and dominating quality in the thinking of managements. Economists have spent much time and written many articles and books on these subjects.

The Effect of Inflation

First, what does inflation do to engineering economy problems? Obviously, a persistent inflationary trend tends to cause a shift in time preferences. Buyers tend to anticipate their needs. They build bigger, and stock larger inventories, because later things will cost more. Perhaps this can be taken into account merely by changing the rate of interest used in the compound interest formulas by means of which time preferences are so elaborately woven through engineering economy studies. Such an attempt runs into a curious dilemma. If inflation becomes much more pronounced, managers may be willing to pay exceptionally high interest rates to get money with which to buy goods in anticipation of continued violently increasing prices. But exceptionally high interest rates in the compound interest formulas tend to give answers favoring postponement of expenditures. Evidently the formulas contain an implicit assumption of constant price levels.

In times of inflation, managerial at-

* Presented before Engineering Economy Committee, June 27, at Lansing, Mich.

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‡ "The Relationship of Cost Accounting and Engineering Economy," *Journal of Engineering Education*, April, 1941.

titudes toward borrowing and investment change. Capital outlays at present prices can save labor—can reduce labor hours—in the future when wage rates will be still higher. By spending on one price level, future savings on a higher price level may be obtained. Moreover, high taxes make growth by plowing back of earnings difficult; accelerated depreciation makes possible tax savings; and renegotiation encourages the accumulation of secret reserves. All this tends to make managements more willing to finance expansion out of borrowing. After all, if a management borrows $100,000 to increase its inventory (speculation?), and if the price rises by 12% in one year, why should such a management balk at an increase in interest rates from 4% to 5%, 6% or even 10%? But, if the compound interest formulas are to give such answers, the interest rate used will have to be much smaller! If the flight from the dollar reaches the stage of galloping inflation, the interest rate used in compound-interest, engineering-economy studies may have to approach the vanishing point. This means the interest rate used in such calculations can have no relation to actual interest rates or to interest rates managers are willing to pay to get money to spend now rather than later.

Such considerations indicate the need for adjustments of historical cost data. To solve a problem in engineering economy correctly, the engineer must turn prophet; he must predict prices. Economics can help him define his problem, to understand its nature, and to solve it. What is the outlook for more inflation? An increasing population tends to produce and to consume more goods, and the supply of money will have to be increased or prices will fall. Increasing productivity per man hour increases the supply of goods to be exchanged by means of the available supply of circulating medium. This, too, indicates a need for a gradual increase in money and bank credit to avoid price declines. On the other hand, government deficits increase the supply of money and, through the way in which they are financed through the banks, tend to increase the supply of bank deposits. So far at least, the Federal Government has found no difficulty in increasing the supply of money and credit fast enough to keep pace with a growing population and an improving technology! Nor does it seem likely that this state of affairs will change soon. Taxes have grown so great, and impinge on so large a part of the voting population, that politicians are reluctant to increase them further. But war and preparation for war, the welfare state, the welter of private interests seeking subsidies, and the general decline in the efficiency of a top-heavy and rapidly growing federal bureaucracy seem to guarantee ever-increasing governmental expenditures. Further inflation seems almost guaranteed for the foreseeable future.

The Impact of Taxes

Secondly, what does our amazing tax structure do to engineering economy problems? With the Federal Government taking almost two-thirds of the profits of business in the income tax alone (including surtax), and coming back for a second helping of from around 20% to as high as 90% of the remaining third when the business pays dividends, taxes have become a major expense item rivaling materials and wages. Managements show a strong preference for expenditures that can be deducted in computing profits on which taxes must be paid. The consulting engineers and the advertising fraternity have made a bonanza of this preference. Their services score as expenses and are currently deductible. Benefits obtained presumably continue far into the future—they are real assets, secret reserves. If an engineering study and a new machine involve equal outlays and offer equal savings, the deductibility feature of the engineering study gives it the manager's preference.

Another aspect of taxes and contract renegotiations that produce an Alice in Wonderland world for the engineer bent on doing for $1 what others do for $2 is

the attitude of managements spending "4¢ dollars." On a consulting job, I tried to get priority for my project by pointing to its cost in consultant fees. "Let's get it done as quickly and as economically as possible," I urged. "Why?" said the manager, "You're deductible. 80% of our business is on war contract where we will be renegotiated down to a profit of around 10% on sales. On that 80%, you don't cost us a thing. On the remaining 20%, we are in the 80% tax bracket, so the government pays 16% and we pay 4%. When we pay your bill, we are spending 4¢ dollars."

Where does this take us? One task that interfered with progress on the consulting job just mentioned was a renegotiation. In the middle of a war, with dreadful urgency for production, the six top executives of this war contractor, and their management consultant, took three days off to write a brief objecting to the profit allowed by a preliminary hearing officer. We took three days off from war, our costs were themselves deductible and therefore came out of the government's share of the company's profits; and in those three days, eight men earned as much money as the 1500 employees of that company earned in a whole year! We got the appeal board to double the % profit allowed. Of course, the government got 80% of this extra profit back under the regular income taxes instead of getting the whole of it by renegotiation.

Other queer things happen to economy studies because of the incidence of taxation. An economy study shows it to be desirable to get rid of ancient machinery. A tax study shows that it had better be kept until a year of greater profits arrives when the deduction will be more useful. Naturally the tax study takes precedence over the engineering economy study. It is dealing with more important factors! Of course, if the economy study went into the comparison of alternatives as far as it should, it would include all the tax computations, and its answers would then turn out to be the right ones.

Governmental Regulation

Thirdly, what does governmental regulation do to engineering economy studies? Obviously, it sets limits to the available alternatives. Copper may be cheaper, or better, but it may also be restricted. Hiring more labor may pay so handsomely that we are willing to raise wages substantially to get the extra men; but a government board may forbid such conduct. We may want to expand our plant facilities, but be unable to get a certificate of necessity which would enable us to do so. We may be pushed into suspending production of our cheaper lines because the government has frozen all prices and we get larger profits from our more expensive products.

Here, again, economics not only helps define the problem. It also supplies a basis for forecasting. All products, and all resources, are interrelated through an amazing network of prices. General movements—rising or falling average prices—depend upon general fiscal factors such as were discussed under inflation above. But within such general movements there are many eddies. Some prices move much farther than the average, others move counter to movements in the general price level. And some prices are much more closely related than others.

First, there are derived demands, demands passed on from one stage of the production process to a preceding stage. Thus, the consumer demand for automobiles becomes in turn a derived demand for steel. Whatever happens to the price of steel tends to be reflected in what happens to the price of automobiles, and vice versa. By noting such economic relationships, and watching for the first changes, subsequent changes can often be foretold with some accuracy.

There are joint demands; demands for products used together: shingles and shingle nails, automobile carburetors and windshields. When a glass factory in Pittsburgh shut down, an automobile factory in Detroit soon ran out of windshields and shut down its assembly lines. Soon

its inventory of carburetors piled up and compelled it to defer delivery schedules, which it turn soon closed a carburetor factory in South Bend. In general, an increase in price of one item in a jointly demanded group tends to raise the price of the group, which tends to reduce the quantities purchased, which tends to force down the prices of the other components of the group. This is obviously something quite different from the general ups and downs of the price cycle, and not controllable by the fiscal policies of the federal government.

Similarly, there are joint supplies; e.g., byproducts. An increase in the price of one of the joint products tends to increase the quantity produced, and the increase in quantity of the other joint products tends to depress their prices.

There are rival demands. When war industries bid up the prices of steel, copper, wool, etc., the competing users must raise their offers or do without.

And there are rival supplies. Kellogg's Cornflakes and Post Toasties, to take commodities from this neighborhood, are rather close rival supplies. Different breakfast foods are more distant competitors. Other foods represent interindustry competition one more step removed. Finally, all foods compete with other consumers' goods. It is alleged that stenographers on Wall Street or on La-Salle Street starve themselves in order to save money to buy clothes, and perhaps incidentally to fit the clothes they want to wear.

These interrelationships may help in predicting many changes of governmental policies and regulations. For example, if price controls succeed in holding down or lowering prices, we know from theoretical considerations that quantities demanded will exceed quantities supplied. Either rationing will be necessary, or the commodity will largely disappear from the market. This, of course, leads to much waste of time standing in queues. Nor do the strong pronouncements of a practical-politician price controller change this matter one iota.

Furthermore, black markets are bound to appear whenever the difference between the official price and the black market price is sufficient to absorb the costs of evading law enforcement. And this is true of smuggling, and of moonshining, as well as of the black market.

Rival supply considerations should warn a price controller that fixing a price on one commodity almost insures the necessity of controlling the price and rationing the supply of all close substitutes. Almost any price fixing and rationing tend to reach out through joint demands and supplies, derived demands, and rival demands and supplies to more and more commodities until virtually all important commodities must come under the price fixing code, with rationing to match.

Finally, the theory of inflation should warn price controllers of the need to reduce inflationary pressures if official prices are to remain close enough to free prices to make black marketing too costly for so narrow a gross margin.

Summary and Conclusion

To summarize and conclude; inflation, taxation, and governmental regulations are newly important factors in many managerial problems of choosing from among alternate policies, product designs, production methods, or productive agents. These factors are now neglected in the literature of engineering economy, but not by economists nor by managers. If the engineer continues to ignore them, he must reconcile himself to seeing his reports filed in the round file; he must reconcile himself to wasting time and money producing reports of little value. Probably problem solving is becoming a matter for teams comprising a variety of specialist experts: an engineer, a tax accountant, an economist, a lawyer, and God knows what next! But these experts must establish effective communication among themselves or the teams cannot function. That means each must have considerable understanding of the problems, the terminology, and the techniques of the others.

How the Library Can Serve Engineering Students*

By JOHN H. MORIARTY
Director of Libraries, Purdue University

Among American people with schooling, the presence and use of library facilities are so taken for granted that their nature is not often considered. The purpose of this presentation is to try to jolt you into taking a fresh look at your library and the use that you and your students make of it.

The Library as Machine

Basically your libraries are machines for serving up books, just as houses are machines for living and cafeterias are machines for eating. To the gentle humanist this has a sacrilegious tone. He feels the library is the heart of the campus or the treasury of man's spiritual life. He probably also thinks of the moon as the queen of the night, rather than a satellite of the earth, 238,840 miles distant. But the astronomer and the librarian have to take the materialistic attitude, and the approach to the library as a machine has very real values.

A second important concept, not often faced by even the librarians, is that the American library is normally a self-service machine. Consider your own library experiences. As a little tot you went into the children's room of your local Carnegie Library and pulled the easy books off the sloping tables; as a young adult you used your high school or public library shelves. In college, you went into the library, spotted the ABC catalog, made out a slip, passed it without a necessary word to a dead-pan clerk and received either your book or checked notice describing its absence from shelf. It was and is all just as mechanical as that. And being American and democratic and used to fending for yourself, you probably really like it that way. I was talking of this to a friend of mine, a columnist on a large midwestern paper. He told me a story on himself, about a use he made of a city library. At 60 years old and the father of a 35 year old son, he remarried. The lady was in her forties and a pleasant companionship was anticipated. Instead at 62 he found he was to become a father again. He was mad at the very idea and disregarded the whole affair as much as he could. On the birthday he assured himself only of his wife's satisfactory condition and let the matter drop. After about three days, on a visit to his wife it dawned upon him that he didn't know the baby's sex. The more he thought of it the more aghast he became. He listened to his wife's talk to the nurse, to the doctor. All of them maddeningly referred to the baby or the child. He left the hospital terrified lest he meet one of his friends and be forced to reveal his indifference, which he now saw was sheer evil. Being an old newsman he headed for a newspaper office but found it was so late that the back issues room was closed. He was standing bewildered in the street when suddenly he realized he was in front of the Public Library. He had it, it was solved. In he hurried and got in line to wait for a paper. "And," he said to me, "if one of you snoopy librarians had asked

* Delivered at a conference of English Division at the ASEE Annual Meeting at East Lansing.

me why I was there, I'd have knocked you down."

But this realization of the library as a self-service machine puts upon the user and the librarian certain very specific responsibilities if the educational effect of the communication potential in libraries is to serve the user for his betterment. This paper is to lay out before you one special corner of this big problem, namely certain peculiar responsibilities of the engineering teacher and engineering librarian within the general situation.

Redesign of Library Service

The standard practice in getting a machine for self-service into general use is to make a market survey of the potential customers and their peculiar problems and to design the machine to take into account these findings, and this, of course, in addition to the regular laws of mechanics which it must obey. And once you have done so, then you institute a sales campaign to educate the public to handle and exploit the machine. The telephone industry illustrates pretty well what I am describing.

What has happened to the marketing of the library as a self-service machine for engineering education is a sad, sad example of how—in any economic world—to go bankrupt in a hurry. No fundamental study of the nature of engineering use of documentation has ever been made. The engineers are not naturally subjective; the librarians have not left off tending the machines long enough to study their effect. As President Edward C. Elliott of Purdue once thundered at me: "The trouble with you librarians is that you don't know what your libraries do to people's minds!" And he was right. What we have done, for lack of basic research, is to improvise and patch. And I for one am tired of worrying about the bare backsides of engineering education which shows through the patches and I'm going to ask you to look at them with me, hoping some of you can figure out how to stretch and mend what we have to make a better fit for our needs.

Break between Classroom and Library

The sharp gap between the classroom and the library is one big hole in our educational front. The path to our present situation goes back some fifty years or so. Up to 1900, the small college library was usually a side or extra job for some professor. At Purdue University at that time the Registrar was librarian too. But at the turn of the century a crisis was reached. Printing presses, based on new printing technology, began to roll; Science and especially the Social Sciences began to record reams of data never before put down—for example the U. S. census of 1870 occupies *one foot of shelf*; for 1880 the census volumes cover *six feet of shelf*. The poor professors, registrars, deans, began pounding on college presidents' desks, demanding relief, help with the mess. They got it; young women trained in library techniques took over, tidied up the mess in a few years, to the intense relief of the administrators. In the administrative relief, nobody stopped to consider that the contact with the teachers and the class room problems and the relations of classroom to library usage, were sacrificed. They were sacrificed, and as libraries grew in size, the break between classroom and library widened.

Now, let me reiterate that nobody was malicious or willfully withholding help or service. All were caught up in a social problem. Libraries, like it or not, were turned into machines I have described. The huge bulk of literature demanded machine precision in handling. Its growth was so rapid as a social phenomenon that the size of library staffs never got to match it or secure even complete mechanical coverage of the material pouring in (the Library of Congress has a backlog of 1,250,000 magazine issues unrecorded. The Nuremburg War Criminal Trial Records, which occupied a full carload going from the ship in New York to Washington, naturally haven't yet been organized). And the presses roll.

Now the best minds in our field of librarianship are naturally in these large

research libraries. If they are overwhelmingly pre-occupied with the raw and material problems of physical control, who is left to consider human use and service of this material on a high plane? Certainly the young girls who come into the library field for two years, five years and then leave really never catch the vision at all.

And there would be some hope for our problems if readers who use the library were more critical.

But most Americans are too active to be really bookish people or to haunt libraries and when occasionally they do venture into the beautiful mausoleums of our large campuses and cities or into the department store type library in the small towns, the average American has a sort of lost feeling. Take the poor student who's been told to write a theme of his own choice. He wanders from shelf to shelf; he toys with the catalog, and finally, he sidles up to the janitor or charlady and says almost off the side of his mouth, "You got anything here on rockets?" And when his teacher does send him to find some one thing, the situation often isn't any better. I'll cite an actual case. A student caught me on the run one day and said Prof. M. wanted him to read a biography of Roger Williams by Vernon Parrington and had said that the Library did have it. He counldn't find it. Well, I did know that Vernon Parrington's death twenty some years ago at an early age with his great work entitled "Main Currents of American Thought" still unfinished is a prime intellectual loss to our country and that Parrington had written too little else. I felt that if he had done a Roger Williams biography, it would be a valuable item on Williams. So I went and looked in the *Dictionary of American Biography* under Williams and in the list of works about Williams, I found Parrington listed not as a biographer but with the reference to Volume I of the "Main Currents" which has the separate title "The Colonial Mind" and has about 100 pages on Williams. This was obviously the biography meant by Prof. M., but how a boy of 19 was supposed to find it with what research skill he had, I confess I do not know.

I do know that there is a bad gap between what orientation to further study is given to students in the class room and the situation they face when they walk into the library. And I know that everyone of you people has as a student faced that too.

Engineering School Library

The gap between classroom and library that I have so far described would be as true of a liberal university as of an engineering school. The engineering school library has all such general weaknesses because as the professional engineering school has developed there has been merely a transfer to it of the library practice used for the humanists and the social scientists, with hardly a thought that an engineering school would require anything peculiar by way of documentation service. The engineering faculties certainly didn't ask for anything different. What they and their students have done is simply to stay away from the libraries. In its way, this absence can be as bitter a complaint as can be lodged.

Library Absenteeism

What was and is back of this library absenteeism? The students stay away because the engineering faculty do not send them to the library. The engineering faculty do not send them to the library because it has been the nature of technical men when pursing knowledge to enquire first personally of someone else who may know. Next, they will test a hunch of theirs in the laboratory. And finally and only finally will they try consultation of the literature, which has seemed to them the least desirable. So you see, the engineering faculty has not sent students to the library because the faculty, following

its two favorite methods, personal exchange between student and instructor and laboratory work, has felt these are enough for all ordinary undergraduates. The ordinary engineering undergraduate has agreed heartily.

The undergraduate's main use of the engineering school library has been generally forced upon him by his non-technical electives. His instructors in English, Speech, etc. are usually the ones who send him to the library and thus all too often, as by a vicious followup punch, he comes to see the written record as having little to do with his major interest, engineering.

Why do I say "vicious"? Is this just because I am a librarian and want more customers? No, it is not; though I won't pretend to disinterest. I feel it is vicious because it imposes a habit toward knowledge that sets a young engineer's career back anywhere from five to ten years.

One glaring fault with all this engineering school picture is the almost total failure to teach the regular reading of technical journals as a device of professional education, particularly of professional self-education.

You all know that no active professional or business man can keep up today who does not read through at least two professional or trade journals a month. The technologies, more even than other fields, are documented almost completely by the journal article. This is a phenomenon of the last fifty years and in many ways our educators do not yet face its meaning. And by this I indict the librarians equally if not more than the engineering or other faculties. We have acted as though the journals were step-children. We solemnly buy, . . . new, texts and monographs with data that are anywhere from two to five years obsolescent. We have spent cataloging and shelving costs on as many as fifteen copies of a textbook, when if an instructor had wanted fifteen subscriptions to one journal for a class we would have gone hot-foot to a dean or president to have that man stopped. We buy one subscription, guard each issue fiercely to prevent any loss of numbers, bind them up promptly, and refuse then to circulate the bound volume. I confess all this because I feel just as apologetic for library practices which prevent students' education as many an engineering teacher has told me he felt about his students' faliure to learn to use the literature.

Engineering Documentation: Now and Later

As engineering education in our expanding technology becomes more and more an introduction to fundamentals and less and less an exercise in current practice, the student needs increasingly a correct orientation toward how he can himself discover current practice. His future experience as a successful engineer facing a new problem will typically be to move (1) from the general awarenes of up-to-date methods which regular reading in his own monthlies such as *Mechanical Engineering* or *Civil Engineering* or some other may give him on to (2) specific journals such as *Materials and Methods* where either articles or advertisements will lead him to (3) catalogs, company handbooks, or direct contact with sales engineers.

This experience is one that every student engineer should have, not once but often enough in his distinctly engineering courses that it becomes for him a set procedure. Beyond this he should have built up by his engineering teachers a literature attitude which is contemporary.

The classic attitude of personal consultation and laboratory testing which I have described above as typical is as of now becoming an old-fashioned and small company or one-engineer-in-the-firm kind of attitude. The larger companies are developing for themselves company libraries sometimes of several thousand volumes. But often these shelves of books may be quite lacking or a bare half dozen. Rather the room will be crowded with filing cases holding engineering reports, clippings, specification sheets, patents, and data sheets of all sorts. The librarian

of such a company will be almost completely receiving, scanning, and abstracting a hundred or more journals which will then be circulated among the engineering or administrative staff.

This is the industrial documentation which our young engineer must face and for which neither academic lecture, laboratory nor library prepares him. By a youngster engineer in a company the right attitude and apt use of such an industrial library can markedly shorten his induction period and give critical boosts in meeting his competition. But the average young engineering graduate is rarely prepared to understand or to exploit such industrial opportunity. Some of the long-standing sorrow over poor report writing might be alleviated if the students could be motivated by an appreciation of American industry's use of the engineering report as industrial documentation and record. Certainly little he sees in academic libraries prepares him for such appreciation.

Ways Out of Our Dilemmas

Now I know many an engineering school librarian will say that no one ever urged him to adjust his library practices so that it will teach students to be at home in an industrial library. And there will be numbers of instructors even of engineering who will see little point to such a set-up spoiling the nice sedate and conventional library to which they are accustomed. Actually too overwhleming a revolution is not required. Industrial firms have often quite handsome libraries. The real revolution is a recognition that the record, the documentation, the literature or what you will has today a part to play in technology's evolution which men trained twenty-five years ago can hardly appreciate. The great industrial firms have set the pace, determined not to infringe patents or duplicate design or work. The librarians however have been no leaders in observing and bringing these new developments into their schools as part of their offerings. But the crust of conservatism is breaking. The engineering faculties are beginning to experiment; the librarians are beginning to bend their practices to fit their users. What then should the progressive engineering school library do for the student? I will close with a brief plea for action on three strategic fronts—the quarters or physical setting, the collection or stock, and the staff.

The quarters, the library rooms, have to be adapted to man, and not demand that man be neurotically quiet, restrained, and unnatural while at study. Small symptoms of such improvement would be the provision for smoking, conversation that didn't distract others, enough space to spread papers, booth-like arrangements giving a sense of privacy, freedom to slip off shoes, drop your head for a nap, and other provisions that would make a man feel at home. Old line librarians will be scandalized at such unseemly public behavior. I'll put up with it and worse if it will contribute one iota to make better prepared engineers. The public polish is a superficial refinement that can and will come later. The library should be a place to study, tailored for men.

As for the collection or books, I have given above the clue to my thinking. Let us haul in the vertical files and beg from industry the raw data of engineering's advances. Why do I stress this? Well, what I want to do is to use the library's materials to motivate our students by the example of live and current applications of the theoretical topics they are studying. A student's inspection of these if astutely timed by his instructor would send the boy back to his thermodynamics text convinced that he'd better have his thermo principles down cold or else. I want to make the wealth and kinds of engineering records a challenge to the student, rather than what the library now is, namely a chore.

And finally the staff has to be looked at. To give the engineering student a break, we'd better get the librarian out of the library at least one-third of the time. At

least that time each week should be spent in faculty consultation. And I don't recommend that the consultation be in the library office. It should be the other way around. The librarian should go out as a salesman to see how the product or service is going over. Only by such a devotion to consumer research and selling can the librarian verify that the library machine is serving its function.

It will be a long time before most of our engineering schools' library service reaches these or comparable goals. The problems of inadequate quarters, inadequate collections, inadequate librarians are real and very human problems. In dealing with these real and human problems, John Dewey has wise obiter dicta for us: "We don't solve such problems. We outgrow them."

College Notes

The Summer Laboratory Course in Techniques and Applications of the Electron Microscope will be given again this summer from June 16 to June 28, 1952, by the Laboratory of Electron Microscopy in the Department of Engineering Physics at **Cornell University**. The course under the direction of the Dr. Benjamin M. Siegel will have Dr. James Hillier of the RCA Laboratories, Princeton, New Jersey, and Dr. C. E. Hall of M.I.T., Cambridge, Mass., as guest lecturers this year.

The course is designed for those research workers, institutional and industrial, who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

The appointment of Bernard E. Proctor to Head of the Department of Food Technology at the **Massachusetts Institute of Technology** was announced by George R. Harrison, Dean of Science at the Institute. Proctor, who is Professor of Food Technology and Director of the Samuel Cate Prescott Laboratories of Food Technology at M.I.T., has been acting head of the department since January 1951.

Transportation of Sediment has been chosen as the theme of the Fifth Hydraulics Conference to be held at Iowa City, Iowa, June 9–11, 1952. This series of triennial conferences is sponsored by the Iowa Institute of Hydraulic Research of the **State University of Iowa**. Topics of the six half-day sessions will include problems of laboratory and field measurement sedimentation in canals, rivers, estuaries, and harbors; and a tour of the Institute laboratories.

Student Evaluation of Teaching Techniques

By HARRY W. CASE

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Introduction

One of the problems that has constantly perplexed educators for a number of years is that of determining the most effective methods of teaching, in terms of learning ease and interest. These two factors undoubtedly significantly influence the rate at which an individual can acquire material presented in a course. As an aid to teachers in formulating their course presentation, the Student-Faculty Evaluation Committee of the American Society for Engineering Education undertook a limited study of teaching techniques during the past year. The problem was approached by undertaking to measure the attitudes of a sample of students toward methods now currently used in the teaching of engineering courses. Unfortunately, the vast array of courses taught in an engineering college and their complexity in terms of content material made it impossible to design a survey for the specific purpose of measuring the most effective method of presentation for a particular subject. Therefore, the survey was designed to cover only the broadest aspects of presentation.

Subjects

The subjects used in the study consisted of some two hundred and nine engineering students divided among six universities—Bradley University, Northwestern University, Ohio University, Pennsylvania State College, the University of California, and the University of Illinois.

The problem was approached by asking members of the Committee to distribute questionnaires to their engineering classes with the request that the students complete the form to the best of their ability. The questionnaire was divided into two parts: the first of which consisted of rating a number of described teaching methods for interest and ease of learning. These were: (1) the uninterrupted lecture, (2) lecture combined with recitation, (3) the entire course based on problem sets, (4) course constructed around student projects, and (5) course including lecture, recitation, problems, and student projects. In the second section provision was made for the student to introduce his own ideas into the evaluation by having him first rate the effectiveness of teaching devices; second, determine the percentage of time that should be allotted for various types of presentation; and third, furnish information concerning the most effective and least effective methods of teaching he had encountered.

Results

If we examine the teaching methods listed in Table I and the relative ratings assigned to them by the students, it is apparent that the more diversified the method of presentation is, the higher it ranks in terms of the students' evaluations. For example, the highest single rating given to any of the listed methods was assigned to the presentation which combines lecture, recitation, problems, and student projects. Following this is the method in which the course is constructed around student projects and the uninterrupted lecture which uses material that is supplemental to the text, both of which rank comparably. Next in ranking is the lecture based on supplemental information combined with recitation, and finally the teaching tech-

TABLE I

TABLE I

	Interest					Learning Ease				
	Excellent	Above Aver.	Average	Below Aver.	Poor	Excellent	Above Aver.	Average	Below Aver.	Poor
Uninterrupted Lecture										
a. The instructor gives an uninterrupted lecture, but deviates little from the content of the text	2%	15%	32%	31%	20%	8%	25%	40%	15%	12%
b. The instructor gives an uninterrupted lecture, but uses material different from but supplemental to the text	22%	43%	25%	8%	2%	13%	38%	37%	8%	4%
c. The instructor gives an uninterrupted lecture, but the material is primarily related to his research and has little to do with the text material	12%	25%	24%	18%	21%	1%	9%	16%	36%	39%
Lecture Combined with Recitation										
a. The instructor gives a lecture deviating little from the text content, but combines this with student recitations	6%	23%	44%	17%	9%	14%	32%	39%	12%	4%
b. The instructor gives a lecture using material that is different from but supplemental to the text, and combines this with student recitations	19%	45%	26%	6%	3%	16%	33%	32%	12%	5%
c. The instructor gives a lecture with material primarily related to his research and having little to do with the text, and combines this with student recitations	7%	20%	29%	23%	21%	2%	5%	22%	41%	30%
Entire Course Based on Problem Sets										
a. The instructor spends the entire period having students place assigned problems with solutions on the board, with little or no comment about each problem	0%	2%	18%	28%	63%	4%	3%	16%	33%	47%
b. The instructor spends the entire period having students place assigned problems with solutions on the board, but gives constructive comments concerning the solutions	7%	24%	37%	23%	8%	10%	31%	36%	21%	3%
c. The instructor spends the entire period having students place assigned problems with solutions on the board, but relates them to the next day's assignment by means of a critical analysis of their solutions	10%	26%	40%	17%	6%	13%	34%	32%	16%	5%
Course Constructed Around Student Projects										
a. Instructor lectures to clarify the scope, techniques, and solution of the project. Students then conduct individual projects and report on them to the class	22%	44%	21%	10%	2%	14%	40%	31%	13%	2%
Course Includes Lecture, Recitation, Problems, and Student Projects										
a. Instructor combines lecture, recitations, problems, and student projects	43%	35%	19%	2%	1%	41%	33%	23%	2%	1%

TABLE II

EFFECTIVENESS OF TEACHING DEVICES

	Most Effective to Least Effective					
	1	2	3	4	5	6
Lecture	41%	25%	20%	8%	4%	3%
Problems	28%	41%	19%	6%	5%	1%
Recitation	5%	17%	25%	25%	15%	13%
Student projects	9%	16%	21%	26%	21%	7%
Film presentations	13%	15%	16%	19%	29%	8%
Other teaching aids	4%	5%	13%	10%	13%	55%

nique in which the entire course is based upon problem sets with little or no comment concerning them.

It will be noted that the students were critical of several lecture techniques. In particular, objections appear to exist to the form of lecture that is related primarily to the instructor's field of research and has little to do with the text. This appears to hold true even though the lecture is broken by recitation. Similarly, although not to the same degree, the technique of simply following the text is considered to be only average. It would be interesting to see whether this technique was preferred by the better or the poorer students.

Analysis of Table I seems to point to the conclusion that the students like problem sets when they are related to the next day's assignments by means of a critical analysis by the instructor. Conversely, they dislike, from the interest and learning ease standpoint, the technique of having problems placed on the board with little or no comment.

The first question in Part II of the questionnaire (Table II) consisted of asking the individual to place a number from 1 to 6 in front of each of six items—1 being the most effective and 6 being the least effective. It will be noted that the students distributed the items in the direct sequence in which they were presented. It is possible that the material was arrayed by chance in the sequence in which the students did select it. However, it must be remembered that the actual arrangement of the items may have influenced their judgment. The second question in Part II read: "Assuming that the total amount of study for any given course equals 100%, how would you distribute the time on a percentage basis for the following activities?" Lecture was assigned 35%, recitation 15%, problem sets

TABLE III

MOST EFFECTIVE METHOD OF TEACHING

(Showing percentage of total students listing the method)

Lecture and problem sets	39%	Lecture and recitation	3%
Straight lecture	18%	Lecture and few problem sets	2%
Straight problems	11%	Projects and problem sets	2%
Projects, lecture, and problems	5%	Lectures and many problems	2%
Lecture and film	5%	Few projects, lecture, and problems	1%
Projects and lecture	4%	Projects, lecture, few problems	.5%
Straight projects	4%	Lecture and laboratory	.5%
All techniques combined	8%	Visual aids alone	.5%

TABLE IV

LEAST EFFECTIVE METHOD OF TEACHING

(Showing percentages of total students listing the method)

Uninterrupted lecture (non-deviating from subject)	22%	Teacher lacks preparation	3%
Lecture entirely on text material	20%	Class lacks participation	3%
No (vague) explanations	8%	All theory, no practical application	3%
Deviation from lecture (much)	8%	Entirely projects	1%
All problems placed on board	6%	Teacher answers questions the entire period	.7%
Entirely problem sets	6%	No homework	.7%
All recitation	5%	Lectures from records	.3%
Problem results not given	5%	Lecture and problem sets	.3%
No problems at all	4%	Lecture and laboratory	.3%
Dull, abstruse lecture	3%		

27%, student projects 13%, other homework 7%, and other 3%—the total equaling 100%. This it should be noted is in general agreement with the other results.

The results to question 3 (Table III) which read: "In my experience and concerning the ease of learning and interest, the most effective method of teaching I have encountered has been—," indicate that lecture and problem sets, straight lecture, and straight problems are the most common selections. It should be noted that in general the information furnished was, unfortunately, not capable of being compiled in the exact form in which it was returned but had to be divided into categories for the purpose of computing percentages.

The question in Part II (Table IV) which read: "In my experience and considering the ease of learning and interest, the least effective method of teaching I have encountered has been—," was answered by the uninterrupted, non-deviating lecture being selected by 22%, and lecture entirely on the text by 20% of the students.

Question 5 of Part II asked whether the

TABLE V

CHARACTERISTICS OF AN OUTSTANDING TEACHER

(Showing the percentages of the total students listing method)

Knows subject	14%	Logical presentation	2%
Good presentation	9%	Available to students	2%
Enthusiasm regarding subject	7%	Organizes material	2%
Understands student	6%	Impartial	2%
Sense of humor	6%	Patient	2%
Good voice	5%	Commands respect	2%
Interested in student problems	5%	No "unrelated" talks	1%
Has personality	5%	Poise	1%
Experience in field taught	4%	Intelligent	1%
Friendly	4%	Fair grader	.8%
Helpful to students	3%	Sincere	.8%
Not egotistical	3%	Good examinations	.7%
Answers questions satisfactorily	3%	Does not lose temper	.5%
Relates subject to life	3%	Strict	.5%
Good appearance	2%	Uses easy terms	.4%
Simplifies ideas	2%	Honest	.1%

most effective or the least effective methods of teaching in their experience were dependent upon the personality of the instructor. To this question 70% indicated yes, 29% indicated no, and 1% qualified it as partly.

The final question of Part II (Table V) asked the students to briefly describe the characteristics that they thought made an outstanding teacher. The most frequent qualities were those related to a knowledge of the subject and the presentation, while the least important items were those related to grading, examinations, and other details of organization.

An examination of the compiled material indicates the impossibility of drawing conclusions that will apply to any one subject. The students' indication of the importance of personality in relationship to the method of teaching should afford clues as to why the assigned rating percentages differ so widely. The survey gives us much to reflect upon when we see, from the students' viewpoint, the undesirability of having an instructor spend the entire period on problems with solutions placed on the board with little or no comment about each problem. From the students' viewpoint there are certain techniques that are more desirable as motivators in the ease with which they enable them to learn the specific material.

However, before we make any generalized conclusions as to the validity and reliability of a study of this nature, it should be pointed out that in the first place this type of study does not afford an indication of the actual knowledge a student will take with him from a course as a result of a specific teaching technique but rather reflects the student's viewpoint of the ease with which he can learn material and the motivation that aids him in acquiring this information. Before even any tentative generalizations can be made concerning the other assumptions, that is, that a student actually acquires a greater amount of knowledge under one technique than under another, it will be necessary to determine the interrelationship of grades to teaching methods.

Conclusions

The following conclusions are tentative and based only on the students' viewpoint and do not necessarily reflect the actual learning that takes place:

1. A course that includes lecture, recitation, problems, and student projects is the most desirable in terms of learning ease and interest.
2. A course in which the instructor uses the entire period for having students place assigned problems with solutions on the board, with little or no comment about each problem, is one of the least desirable techniques.
3. About 35% of the total time involved should be devoted to lecture, about 27% of the total time to problem sets, 15% to recitation, 13% to student projects, 7% to other homework, and about 3% to additional activities.
4. The students believe that the method of teaching, in terms of its effectiveness, is dependent upon the personality of the instructor.

A General Curriculum for Agricultural Engineers*

By L. W. HURLBUT

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The prime responsibility involved in planning for a college education centers in the preparation of students for subsequent continuous development in their chosen field and good community life. Whatever contributes significantly to this end deserves our wholehearted support.

In Agricultural Engineering, we are relating a complex profession to a most complex industry. Yet, there is ample evidence to indicate that we need not lament the fact that there is insufficient time in our undergraduate curriculum for all the "good" courses that could be offered in engineering and/or agriculture. It behooves us to be very selective in preparing a series of well-integrated courses and presenting them with enthusiasm. The curriculum must be planned to develop intellectual maturity for the student with due consideration of time and money involved.

More specifically, our ultimate objective is to produce good Agricultural Engineering graduates in possession of a relatively high degree of intellectual maturity including good fundamental training, an enthusiastic attitude toward their work, and a full confidence in their ability to get the facts necessary to solve problems and get jobs done. A graduate Agricultural Engineer who needs a course before he can attack a new problem lacks in such maturity.

* Presented at the Agricultural Engineering Conference at the Annual Meeting of the ASEE, East Lansing, Michigan, June 28, 1951.

Factors Involved in Planning A General Curriculum

The main factors involved in planning a general engineering curriculum appear to be about the same as those involved in planning any other curriculum. They include the student, the instructor, the course plan, and the primary field of interest during and subsequent to college. The curriculum itself is merely the plan by which the philosophy of the college, the department, or the profession is implemented.

The student brings personality, character, ambition, resourcefulness, and technical ability in varying degrees of development. He commonly selects Agricultural Engineering because of an interest in solving problems of a physical nature and a deep interest in agriculture and rural people. The problems he knows as a pre-engineering student may or may not be those with which the Agricultural Engineer is daily involved—but, nevertheless, past events influence his choice. As a freshman, he may bear some dislike for the requirement that time be spent on courses other than the chosen field. Therefore, one of the first things to be learned is that an engineering education in a democracy must recognize three distinct areas of interest and development. The first area deals with him as an individual; the second with him as a citizen or one of a group of workers; and the third with him as a Professional Engineer. Broad interests generally are not inherent in most high school graduates so it is up to the

college teacher, and the curriculum, to provide for the stimulation of these interests.

Teacher is Important Factor

The teachers will probably rank second in importance to the student and greater in importance than the curriculum. The statement that the teacher is a very important factor in a program of education is well substantiated by interviewers who consistently claim that they can quickly spot student interests paralleling those of the influential instructors. The teachers and their courses in the curriculum must:

1. Transfer the requisite factual information to the student.
2. Develop confidence in his ability to learn; good engineering teaching is generally considered to be the development of the student's ability to do things for himself.
3. Develop the student's confidence in his ability to discriminate among values and make intelligent judgments.
4. Improve his methods of expression through speaking, writing and drawing.
5. Help develop character, personality, and citizenship.

These requirements definitely suggest a general curriculum and good instructors. The ideal instructors for courses in a general curriculum are not easy to find. First of all, they should be scholarly specialists, yet, each have a broad outlook and an engaging personality. They should be skillful and inspiring teachers and have an active interest in public affairs. They should be engaged in research, and have an interest in administrative procedures. They should have industrial or professional practice as a background for selecting practical applications wisely, and presenting practical experiences vividly. It is evident that there must be some compromise with the faculty as well as with the curriculum, but this situation need not alter our aims and ideals.

The curriculum forms the steps toward achievement of intellectual competence and maturity. Three stages of student development can be fairly clearly recognized in the technical part of our general curriculum. In the first stage, the student learns facts. The second stage involves the selection of facts and the fitting of them together into an organized whole. The third stage develops the disciplined ability to discriminate between facts, analyze situations, and basic practice in creative ability—that is, to devise solutions to relatively complex problems.

In a program of such progressive general development, the courses must be arranged in well integrated sequences with each advanced course building on fundamentals already developed. The content of each course must be planned to keep fundamental laws before the student and to provoke the realization that complex problems involve a number of less complex elements. The objective is continuity of experience expressed in the various phases of study.

MINIMUM REQUIREMENTS FOR THE AGRICULTURAL ENGINEERING GROUP (2)

Agriculture and Agricultural Engineering—Agron 53; Agr. Options, 9 hrs; AE 5, 7, 123, 223, 225, 243, 244, 254	41 hours
Mathematics 14, 16, 17, 105, 106, 107	19 hours
General Engineering—EM 1, 2, 3, 4, 121, 225; CE 219; EE 101; Eng. 1, 50, 100	24 hours
Physics 103 and 104	10 hours
Chemistry 3 and 4	6 hours
English Usage—Eng. 3, 4; Speech 111	9 hours
Military or Naval Science	4 hours
Non-Technical Options	15 hours
Technical Options	8 hours
Orientation (freshmen)	0 hours
Total	136 hours

It is important to note that our general curriculum plan suggests that a certain amount of specialization is necessary in order to prepare the student for the

more complex problems. This condition necessitates that judicious compromises be made in developing both broadness in thinking and broadness in subject matter. Broadness in thinking comes in building new elements, through the various phases of Agricultural Engineering, upon the physical sciences, mathematics, basic engineering courses, economics, and humanities. There must also be a proper balance between the applicational and theoretical aspects of the subject matter. It is important to recognize that student engineers are basically intensely practical people and they expect practical features to appear in the college course work. Furthermore, before acquiring a mature status, the new graduate must generally serve some time as a sub-professional and at this level he may be called on to produce in competition with craftsmen from trade schools. Therefore, he must have limited confidence in, and basic practice with, the tools and methods of the craftsman.

The curriculum adopted by our faculty begins the development of broad versatility in the freshman year. The start is made in a course entitled "Introduction to Engineering" presented by Dean R. M. Green and his staff. The course description reads, "Survey of requirements in the various fields of engineering; services performed by Engineers, civic and ethical implications of the practice of engineering, characteristics of the fundamental requirements." Subsequently, the student selects fifteen hours of "non-technical" electives which are at the level of his college standing.

The climax to work in the three areas, aforementioned, comes in Engineering 100, a senior course, again presented by Dean Green and staff. The course description reads, "Professional relations, personal requirements, civic responsibilities and ethical obligations for engineering practice. Legal registration of engineers and architects. Sub-professional and professional services. Changing conditions in engineering practice. Requirements for placement in engineering." The two courses, Engineering 1 and 100, serve as the framework which binds together the three distinct areas.

Broad Versatility is Required by Employers

The employment pattern of Agricultural Engineers shows a very broad use of their talents beyond the professional phases of development and design; and this is an important element to be considered. This consideration is important for other branches of engineering too. For example, a recent report received from the International Harvester Company (1) indicates that in 1890 industry employed one engineer for every 300 other employees, whereas in 1950, one engineer was required for every 69 employees.

An attempt has been made by Martin John Bergen (3) and others in the E. I. du Pont de Nemours and Co., Inc., Newark, Deleware, to evaluate the professional performance of a large number of workers representing the entire field of engineering design. The objective was to determine whether or not a "work" function could be derived from Performance Rating data. The study indicates that eight important variables grouped themselves naturally into two groups—the first group consisted of those factors which were learned primarily by formal schooling, called "Ability and Knowledge" factors. These included:

1. Knowledge.
2. Analytical ability.
3. Ability to learn new duties.
4. Ability to write and speak clearly.

The second group were called the "Psychological and Personality" factors and they were:

1. Cooperation.
2. Initiative and creativeness.
3. Judgment and common sense.
4. Supervisory ability or leadership.

As expected, the various factors were found to be interdependent. It was concluded that in the more responsible posi-

tions the company was paying two dollars for the "Psychological and Personality" factors for every dollar paid for the "Ability and Knowledge" factors. The "Ability and Knowledge" factors presented practically no difficulty because these were the factors that had been specified and for which there was some measure. This study serves well to indicate the importance of the "Psychological and Personality" factors. These latter factors are extremely important to the individual, his family, and industry. They are intimately associated with group attitudes. The striking contrast between problems relating to technical efficiency in industry on one hand and matters of human cooperation on the other is well recognized in the general curriculum. Furthermore, the formal requirements of the curriculum are adequately supported with opportunities and obligations in the extra-curricular life of the student engineer. This latter feature is also an important factor to be considered in helping a student plan the use of his time in college.

A review of the present placement of the 196 Agricultural Engineering graduates from the University of Nebraska indicates that they have the basic training necessary for entry into almost every field where there are problems of maintenance, production, development, design and distribution. Their assets are a good basic engineering training, fundamental training in non-engineering courses important in their living and working, and a farm background where they have had many opportunities to solve real problems requiring thinking in terms of economic results.

Summary

1. No practical undergraduate curriculum can provide all the training necessary to the graduate in his subsequent life, and it is impossible to predict his future activities accurately. The study plan needs to provide only limited opportunity, if any, for specialization. A real problem in curriculum and course planning is to determine what fundamentals are important.

2. If the graduate is trained in broad fundamentals properly supplemented by practical applications in his general field of interest and instilled with a burning enthusiasm for engineering work in that field, it is quite likely that he will grow thereafter with additional study as the needs of his life unfold.

3. A graduate program based upon advanced technical subject matter should be available so that more specialized study may be pursued with a vigor consistent with such preparation.

4. The student, the teacher, the curriculum, and the employer should be guided in their judgments by the fact that the undergraduate curricula and college life are near the beginning, not the end, of an engineering career.

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Doctoral Study in Industrial Engineering*

By NORMAN N. BARISH

Associate Professor of Management Engineering, New York University

Doctoral study in industrial engineering is relatively new. Prior to World War II, very few schools had organized instructional programs leading to doctorates in industrial engineering and few doctoral degrees in this field were awarded. Some indication of the growth in this field is given by the fact that in 1933–34, no doctorates were awarded in industrial engineering whereas four doctorates were awarded in 1948–49 and three were awarded in 1949–50. There were five doctoral students in industrial engineering in 1933–34 whereas there were fifty-nine in October 1949 and there were forty-three in October 1950.

To obtain data on current practice among a number of schools awarding doctorates in industrial engineering, a questionnaire was sent to the eight schools reporting doctoral students in the ASEE—U. S. Office of Education annual enrollment survey. Replies were received from the following seven schools: Columbia University, Iowa State College, Johns Hopkins University, New York University, Ohio State University, Pennsylvania State College, and Washington University (St. Louis).

The practices and experiences of these schools are generally quite new. Many are still in the process of developing their approaches to the questions discussed in this paper. It is hoped that this discussion of some of the problems and present practices will prove helpful in the further development of effective doctoral study programs in industrial engineering.

* Presented before the Industrial Engineering Division at the 59th Annual Meeting of the ASEE, June 25–29, 1951, in East Lansing, Michigan.

Objectives of Doctoral Study

The aims of doctoral study in industrial engineering may be categorized as follows:

1. The extension of the technical knowledge and competence of the candidate in the fields of industrial engineering to a sufficiently high level that he may be considered to have mastered the principles important to practice in these fields.
2. The equipment of the candidate with substantial tools for scientific analysis and independent rational exploration and performance in industrial engineering fields.
3. The contribution by the candidate to knowledge of a particular phase of industrial engineering. This last aim is usually served by the performance of an original investigation.

When a school has adequately accomplished these aims in its doctoral training, it will award doctoral degrees to candidates who are able to: recognize industrial engineering problems wherever they exist; discern the true nature of the problems; devise an intelligent approach to the solution of the problems; execute the investigations required by this rational conception of the problem solution; design effective and efficient experiments to test the validity and reliability of his solutions; collect and digest his data; correctly analyze and properly evaluate the results of his experiments; record his results and conclusions in a clear manner which is understandable to his fellow industrial workers; and give effect to his conclusions by selling himself and his rec-

ommendations and by following through with training and installation of procedures where required.

The survey disclosed differing emphases on some aspects of these goals by various schools. One department considered its principal goals "the development of men who can think independently; can bring a creative viewpoint to the analysis of problems; can use the English language with correctness and facility in exposition; have sufficient fundamental knowledge of the field and the surrounding fields to be competent in the evaluation and/or direction of research in the field." Another department considered its purposes "to train industrial engineers of full professional competence, with a sound science—humanities background including psychology, sociology, economics, et cetera. The goal of such people should be to improve present inadequacies in industrial engineering practice by research and application." A third stated its objectives more broadly: "to qualify candidate for unusually successful industrial career; to qualify candidate for teaching career; to contribute significantly to fund of knowledge in Industrial Engineering or Industrial Psychology."

Responsibility for Personality Training

It is apparent that, by and large, the various departments feel that their aim is to educate rather than train—to promote the study of fundamental principles which are capable of broad application and which will develop the capacity of the individual to perform successfully in industrial engineering fields rather than the acquisition of skills in the use of specialized techniques. A mature personality with abilities for cooperative action as well as creative independent thinking and scientific curiosity is important in the enlargement of the individual's performance capacity.

However, opinion on the question of responsibility for personality training of doctoral students is quite varied. Two departments replied that they considered that they had a responsibility for personality training and one of them included specific course work. Two others considered that they had a responsibility for bringing any personality deficiencies to the student's attention for his own corrective action. One school was not too sure if it had any responsibilities for personality training and one stated emphatically that it had none. Another asked "can you 'train' personality?"

Screening Procedures

Not all industrial engineering students are likely material for doctoral study. While many of the abilities previously outlined can be acquired through study and training, the candidate must possess a certain minimum of inherent creative powers if he is to successfully complete a high calibre doctoral program.

With small numbers of full-time students, informal methods of restricting enrollment to qualified persons may frequently be adequate. With the larger number of students currently seeking advanced degrees in industrial engineering, many on a part-time basis, formal screening procedures are required to maintain high standards of scholarship in doctoral studies and to save the time and efforts of persons who are not endowed with the necessary qualifications. This screening process is most effective when it exerts its principal effects at the earliest stages of doctoral study.

Admission to Graduate Study

Admission of doctoral students to graduate study is generally limited to properly qualified students on the basis of the satisfactory completion of minimum academic undergraduate requirements. The student's undergraduate record, his standing in his graduating class, and the recommendations of his instructors are all used to varying degrees to ascertain the qualifications of the student.

Five of the seven schools require an undergraduate degree in engineering. Four of these five schools have definite

specified undergraduate course requirements whereas the other three schools appear to have rather flexible requirements. The four schools require that, in addition to meeting all undergraduate prerequisites for graduate courses, the student must complete specified undergraduate industrial engineering courses in such fields as: industrial organization and management, engineering economics, statistics, accounting and cost accounting, production and factory planning, motion and time study, quality control, psychology, physiology, et cetera. No school requires all of these courses and the emphases show wide variations. One school reports an attempt to break away from formal, rigid admission standards, requiring only "a broad general stipulation of science—humanities."

Admission to Candidacy

All schools give examinations for admission to candidacy. The examinations are comprehensive, covering a wide area of industrial engineering and some related fields. They are written by the department staff (plus, in some cases, members from other departments concerned with the doctoral courses of study) and therefore reflect, to some extent, the point of view and interests of these persons.

The subject emphasis on these examinations show some basic uniformity with quite a variety of stress given to fringe fields. As would be expected, all seven schools appear to give an important role to what is normally called industrial organization and management. Six schools mention some aspects of economics: four specify engineering economy, one political economy, and one does not specify the kind of economics. Four departments mention the following subjects: production planning and control, psychology, quality control, and accounting fields. Three mention the general field of methods study (work simplification and motion and time study). Two mention statistics, personnel, safety, and mathematics. Other fields mentioned by individual schools include tool design, industrial experimentation, and industrial forecasting. This tabulation gives a rough picture of the fields covered in the doctoral qualifying examinations. The subject matters of the fields overlap and the amount of emphasis within each school was not considered.

Two schools mention that they give a case problem type of examination. At one of these schools (N. Y. U.), an actual company is chosen and, with some modifications, a descriptive package is prepared on the products, markets, facilities and layouts, personnel, production methods, organization, financial status and history, product design and development, inspection and quality control procedures, sales and marketing policies, et cetera. This package is mailed to the candidate several weeks in advance of the date of the examination. The candidate is then questioned in both the written and oral portions of the examination to determine his technical competence in the various fields of industrial engineering and his ability to integrate and apply his knowledge to this company's problems.

The oral portion of the examination may frequently be more revealing of the candidate's abilities and capacities than the written part because it allows the examiner to determine more thoroughly the limits of the student's understanding of the problems. Thus five of the seven schools reported that their examinations for admission to candidacy have both written and oral portions. One gives a written examination but the examining committee may give an oral examination if it deems one necessary. Another school's examination is entirely oral.

Research and Thesis Requirements

The thesis undertaking serves several purposes: it provides a medium for disciplining the candidate in logical methods of thought as well as for maturing and testing his research ability; it provides training in effective self-expression; and it furnishes a mechanism for promoting

independent investigations for extending the boundaries of knowledge in the field. In general, the doctoral thesis should be related to the individual's interests and occupational plans as closely as possible because it will then have a functional interest and meaning to him which may otherwise be lacking.

Satisfactory definition of what is an acceptable research undertaking is difficult. Some quotations from the schools indicate the trends in industrial engineering departments: "Thoroughly competent study of a definable section of industrial management; the production of a valid contribution to knowledge in that section; production of a publishable thesis or abstract of that thesis"; "(1) Original; (2) Fundamental rather than application; (3) Laboratory investigation preferred to library research; (4) Philosophic development, including hypothesis and experimental trials to prove or disprove"; "I prefer advancements of general methodology and theory supported by experimental evidence."

Course Requirements

Because the doctorate is not awarded on the basis of the accumulation of a given number of graduate credits, variations in the minimum number of credits required for the degree are not of much significance. Many schools regularly require more than the minimum number in their approved doctoral programs and the bases for evaluating and assigning credit points to graduate courses and research and thesis work are quite varied. The basic universal requirement appears to be three years of full-time work after the bachelor's degree, of which approximately one year is supposed to be spent on research and dissertation (which may sometimes be performed concurrently with parts of the two years of course work).

Rigid course requirements for the doctorate reduce programming flexibility. Superior students are required to cover material in which they are already proficient. Candidates with unusual interest combinations are discouraged from following a logical, but out-of-the-ordinary, program. Only three of the seven schools require that all doctoral students take a specified list of graduate courses, varying from four to eight courses. These course requirements correlate quite closely with the subject emphases on the Admission to Candidacy examination. The remaining four schools do not presently have such course requirements. One of these latter schools indicates that it very definitely seeks an absence of the rigidity which such requirements impose.

Five schools have a requirement that courses be taken in one or more minor fields. Two of these five recommend, but do not always require, two minor fields. One of the schools which does not require a minor advises its students to take minors in economics and psychology.

Seminar type of instruction is used extensively by most departments. In one school which has small enrollments, all its instruction approaches the seminar type. Another department uses the seminar type instruction practically all the time after the first post-bachelor year. As might be expected, the schools with the large enrollments do not appear to use seminar type instruction to anywhere near as great an extent as those with smaller enrollments.

Experience and Personality Requirements

One school requires that the doctoral student have "substantial professional experience." This usually means about five years or more, but it allows for weighting according to the nature of the experience. Another has no defined requirements, but will allow experience to be substituted for undergraduate course deficiencies. The other schools have no experience requirements, although one reports that all candidates in the past have had experience.

Three of the seven departments stated that their doctoral students are supposed to have personality characteristics indicative of successful professional performance. These schools indicated that they

considered personality characteristics to the extent that they will affect the candidates' professional careers. One of the four who reported no requirements answered the question of whether it thought a school should have them with the reply: "Yes if valid requirements could be established. How do you do it?"

Language Requirements

All schools have foreign language requirements for the doctorate. Three require one language, three require two languages, and one requires either a comprehensive knowledge of one or a dictionary knowledge of two.

Opinion was divided on whether these language requirements are correct and valid or might be considered a relic of the past. Most departments seemed to incline toward the latter view. "Essentially a hurdle." "Should be eliminated in favor of additional course work or research." Two other schools considered the language requirements a relic to some extent, but one of these thought that it might be worthwhile for training men of broader perspective. Only one school was strongly in favor of the requirement, emphasizing, however, that steps must be taken to make it significant.

Breadth and Integration of Knowledge

Ours is the age of specialists. There was a time when the family doctor worried about and cared for the entire body of his patients from infancy through old age. Nowadays, the baby is delivered by an obstetrician and is cared for in infancy and childhood by a pediatrician. You consult one doctor about your throat, another about your nose, and a third about your ankle. There is much to be said for this procedure: with the increasingly enlarged boundaries of knowledge, it is difficult for a man to become expert in more than one or a few specialties. There is thus a growing tendency for each person to narrow his field and intensively cultivate his own little garden.

This high degree of specialization in our modern industrial society produces a serious coordination problem. Is the treatment of the nose coordinated with the treatment of the throat? In considering problems of the ankle, does the doctor consider its relation to the foot? In other words, does the doctor have perspective?

Everywhere, including our own field of industrial engineering, there is a growing army of specialists who lack perspective. Doctoral study programs are confronted with the problem of counteracting this trend. The candidate should become expert in his chosen area of specialization. However, this should not be accomplished at the expense of a good broad perspective. The doctoral candidate should have breadth of knowledge in all fields of industrial engineering and management and should be able to integrate his knowledge of these specialized fields. He should be able to tie his thorough acquaintance with these specialized fields to the vast expanse of related human knowledge.

ANNUAL MEETING

June 23–27, 1952

Dartmouth College **Hanover, N.H.**

Four Year vs. Five Year Engineering Course

By GEORGE J. BARKER

Chairman, Department of Mining and Metallurgy, University of Wisconsin

I have been asked if I would discuss the four year educational program as compared to the five year course. First, allow me to make it clear that I am not opposed to a five year program but that I am in favor of the four year plan under present unsettled conditions of our national economy. All of us are entitled to our own opinions and beliefs and we should act accordingly when we build an educational program. However, we should be absolutely sure that our opinions are right and our plans are the very best of our thinking before we accept a program to be inflicted upon a young student entering the engineering profession.

I clearly remember many years ago I was a strong advocate of the five year scholastic program. I almost said the "five year plan" but hastened to change the wording in fear of being asked to appear before an investigating committee in Washington. It was at the annual meeting of this Society in 1939 at Pennsylvania State College that the five year curriculum was discussed pro and con. One of the officers of the Society made the public statement in the meeting that, whether we liked it or not, the five year program was to be forced upon us and we would be compelled to accept it. I felt that this was an unfortunate statement because whenever you tell an engineer in the educational field he will be compelled to teach in a manner with which he is not in full agreement, you create an antagonism which can be a very destructive force. Personally, I feel the antagonism generated at that time prevented the five year course from being generally accepted by our engineering colleges.

To me it is not a question of whether we teach a student for four or five years. The important point is what do we teach and how well do we impart knowledge and a desire to learn to the student.

Present Curricula Out of Date

Speaking personally, this is my own opinion and is not meant to cast reflections on any one. I am firmly convinced our present curricula, whether it be for four or five years, is completely out of date. When I entered the university the main mode of travel was by horse and buggy. Then came the auto, the airplane, and now the jet. We have made vast strides in our mode of living but ask yourself if we have made the same progress in building curricula. If you examine the various programs for the freshman engineer you find most of us require English, Mathematics, Chemistry and Drawing. This is exactly the same program required thirty years ago. And why have we not changed it and kept abreast of progress? Is it because whenever we are about to change a program we examine the catalogs of like institutions and say, "This is what the others are doing"? This course of following blindly in the footsteps of others is not progress. If we are to keep abreast of the world as it is developing today we must change our program. By change I do not mean to a five year course but, rather, a change in the present four year course. For instance, why should we not remove English from the freshman year? Such a proposal shocks you because you can hear the howl of protests that immediately would arise. However, if you will carefully examine the

question you must eventually arrive at the conclusion that there is no good reason for teaching English in the freshman year except that that is where it has always been taught and to change it would be a sacrilege. I can advance many arguments why it should be changed but the important one would be that the manner in which English is taught today to our freshman students is a practical waste of the student's time—time which is so valuable and should be used to better advantage in the student's curriculum.

Teaching Assignments

While I am on this subject of suggesting ways of making a better engineering course, could I give you one more example of what is wrong in our education work? Most of you are familiar with the cost of education and you know that it is common practice to employ many graduate students for part time instruction to keep down the cost. Most of these instructors are assigned to freshman instruction. I am fully aware of the advantage of having the pioneering spirit of youth and the experience of age on the teaching staff, but I am firmly convinced we are making a serious and costly mistake in our classroom teaching assignments. I would favor the assignment of the experienced teacher to the lower level classes and to graduate teaching, with the younger instructors handling part of the upper classes. All of you have deplored the heavy casualty list of students in the first year in the universities. We pass it off by saying the student "just has not got it" and should be eliminated from further education. I say this is morally wrong. We should give the young student the very best of inspired instruction and salvage this staggering loss of humanity which is a disgrace to our educational system. There is an additional advantage to the proposed system of using younger instructors to teach upper classmen. They would know it would be necessary to better prepare their class instruction and this would materially improve their own knowledge of the subject matter.

I am sure many of you have been placed under some pressure recently by some of the propaganda which has been fed us, namely, technological development, which has been so rapid recently that society has not been able to keep pace and adjust itself and that engineering should slow down until the social sciences can catch up. Also, the engineer should include more humanistic and social studies in his program. This, as has been pointed out, could be done by lengthening the student's time to five years in college. In general, I am opposed to this plan. As an engineer you look at facts and base your decision upon these facts. So, let us examine the facts. By far and large, the greater number of students in colleges today are taking the humanities and social courses.

For the past generation graduates of these courses have taken their place in society and, because of college training, have assumed places of responsibility. Presumably, many of them have entered public service and it is only necessary to take a quick glance at the situation in Washington today to make us realize what a failure our general educational system has been. Today the plea is for the engineering students to take more humanistic and social studies so they may be better fitted to enter into the affairs of our national government. To me such a plea is not worthy of consideration by any clear thinging engineer. Our engineering graduates of today are far better trained for public service than any other group of students. And why? Because we, by engineering training, have taught the student to analyze the facts and then proceed on these facts in an *honest* manner. The one word, honesty, is the key to the whole situation. We teach honesty to ourselves and then honesty to others follows automatically. I repeat, the engineer is now receiving this training and because of it, he better understands the rights of others,

and has a clear concept of the problems of humanity.

And, so, I do not favor at this time addition of so-called social and humanistic studies to an engineering curriculum, but I do advocate the inclusion of engineering courses into the liberal arts curriculum so those students may at least have some contact with clear and logical thinking. By this same reasoning, I cannot agree that the five year course has some advantage over the four year course, simply because it allows more time for the student to receive a more so-called liberal education.

Strengthen Course Content

Coming back to the main question of the four year curriculum, this should not be lengthened but the course content should be strengthened. With the present acute demand for graduates we should supply the need as rapidly as it is possible to send out adequately trained men. With the high cost of living and the loss of present high wages paid to graduating engineers, you can estimate it will cost a boy, roughly, five thousand dollars to spend an extra year in college. This is an economic waste, provided we do a good job in teaching the student during the four years he is with us. Our engineering graduates enter so many various fields of endeavor, it would be impossible and very foolish to try to give complete and adequate instruction in every field which offers employment. Therefore, it is essential that our four years' training be concentrated on a thorough mastery of the fundamentals of the various fields. We must not build a curriculum on credit hours but upon course content. If the graduating student has received sound training in the fundamentals, his prospective employer knows he can give the graduate the necessary training to fit him for the position for which he was hired. In general, large industries which are hiring our graduates are not asking for more special training but actually will accept less if the student has been well trained in the fundamentals.

I am very willing to acknowledge some few students can and will benefit by longer training. If the particular individual desires to specialize in a particular field, to do advanced work or train for research, then he should enter the graduate school for this additional training. Most universities have strong graduate courses and the additional training is available if desired by the few.

In my early engineering training I readily learned the value of the courage of my convictions. Today I have the courage and, because of it, will be convicted by some of you. It has been a pleasure to inflict upon you some of my thoughts and ideas. I know many of you will not agree with me but I sincerely hope I have set forth ideas to which you will give careful consideration and by this consideration improve the quality of our engineering graduates.

* * * *

Electrical Engineering Summer School

The Electrical Engineering Division will hold a Summer School at Dartmouth College on June 20 and 21, 1952. The theme will be "Undergraduate Teaching of Electrical Circuits and Fields." Registration will be $1.50. For further details address Dr. J. C. Ryder, Electrical Engineering Department, University of Illinois, Urbana, Illinois.

The Electronics and Communications Options—Why?

By J. D. RYDER

Professor and Head of the Electrical Engineering Department, University of Illinois

It does not seem possible to discuss curriculum options in electrical engineering education until we know what we are trying to accomplish, or what are the objectives of electrical engineering education. We are given certain raw material from the high schools. What sort of product do we wish to make of that material four or five years hence? If we have an answer to the type of product desired we are then in a much better position to determine what processes should be applied to the material during the period of manufacture. Industry, as our customer, frequently tells us what qualities they desire in that product, but they are in no position to indicate the manufacturing processes we are to use.

At the moment it appears that industry would like a graduate having two somewhat contradictory abilities; namely, a technical level of achievement considerably higher than that expected 30 years ago, and the ability to live and work with other people. The objective of our academic efforts should be directed toward satisfying that demand.

It has occasionally been said that an engineering education should be sufficient to enable a graduate to hold a job for a few years until he could learn to be an engineer. If this is the objective of our teaching efforts we should so inform our students, since we are obviously not planning to deliver that which they expect. Such an objective appears to place some sort of a top limit on our teaching efforts since we seem to have stated that we are unable to prepare a man for anything more than a job immediately upon graduation. The training of a man to hold a specific job is the objective of a trade school and not one which should be fitting to an institution of higher learning.

Even if this statement were our actual objective it is not a desirable one since it seems to say that our objectives are limited, that our efforts can only accomplish so much, therefore why attempt to accomplish more? It seems more desirable to have as an objective some statement which furnishes a goal, not a limit, to our efforts.

There are, of course, those who will argue that we cannot turn out engineers but can only teach engineering, and to some extent this is true; however, it can also be argued that we should attempt to teach our engineering in such a way as to make the best possible engineers fifteen or twenty years after graduation, and it does not seem that the above objective supplies the proper incentive for that kind of teaching.

Objectives

It seems desirable to propose as an objective of electrical engineering education:

> Upon completion of their college work, our graduates should be prepared to continue learning, to grow with the field, and to go with that field as it moves into new areas of learning.

Our objectives are then stated so as to lead us on as a path into the distance rather than in a form which serves as a

closed gate. Our graduates should be prepared to meet and solve new problems as they arise, which means that they should have understanding rather than superficial knowledge, and should be taught the fundamentals to many problems rather than solutions to a few. We should prepare our graduates to meet and understand new systems and new devices as they arise, and should not allow to be again repeated the troubles of a 60 cycle power man upon the advent of radio and electronics.

Much of the above seems to be an argument for the teaching of fundamentals. It is then proper to ask—if only fundamentals are taught why are curriculum options necessary since the fundamentals are the same for all?

It seems that such a question carries at least an implied premise, and may imply agreement with a fallacy. That is, are the fundamentals in *usable form* really the same for all types of electrical engineering problems?

We might argue that an understanding of the reactances of the synchronous motor is fundamental to the study of that machine for a power student. We could likewise argue that understanding of the orientation of the magnetic field in a TM_{10} excited wave guide is fundamental to the understanding of electromagnetic propagation in guides for a communication student. Thus the fundamentals are not the same for all since we can hardly argue that a vice versa relationship of understanding by our two hypothetical students is essential to success in their respective fields.

If one wishes to argue that these two examples are not fundamental but are merely applications, it is possible to reason back step by step until one comes to the realization that the common ground for our two students and therefore the common fundamentals of the problem lie in the understanding of the transmission of energy through electric and magnetic fields.

If only the fundamentals are to be taught in this area of knowledge, we will teach our students that the energy in a magnetic field is expressed by $\mu H^2/2$ and the energy in an electric field is given by $\epsilon E^2/2$. We cannot teach the students that the rate of flow of this energy through the electromagnetic field is given by $E \times H$ or Poynting's vector since someone will point out that is an expression used predominantly in the communications area and is therefore not a fundamental for all students. We might also attempt to teach machines to our students by considering the magnetic field only, which is the usual teaching method for machines, but our radio friends will immediately point out that there must be an accompanying electric field wherever there are time-or space-varying magnetic fields, and therefore, such a consideration of the magnetic field alone is not fundamental.

This dilemma might be resolved by a proposal to teach the true fundamentals, Maxwell's equations, in which the actions of fields in synchronous machines or in the wave guide are mathematically described. We can, of course, immediately expect the power-interested faculty to argue that those equations have little use in the machine area. In return it might be stated without further proof that these equations are little *used* there, but actually could be of considerable help in certain anomalous situations.

Fundamental Knowledge vs. Fundamental Methods and Techniques

It seems proper to suggest that we are confused between the teaching of *fundamental knowledge* and the teaching of fundamental *methods and techniques* to use that knowledge. Our fundamental knowledge may be considered as wrapped up in Maxwell's equations, Newton's laws, and the conservation of energy and momentum, subjects which can be readily taught. However, as illustrated by our example of the students being taught magnetic fields in machines and wave guides, teaching of only these common fundamentals leaves our student ignorant of the higher level methods and techniques which

can make that fundamental knowledge useful.

These methods on which we spend so much time may include complex algebra, vector diagrams, graphical solutions, flux plotting, harmonic analysis, symmetrical components, the vacuum-tube equivalent circuit, the Laplace transform, and many more. It is these methods on which we concentrate and an electrical graduate would be in a rather poor position if we denied him these techniques.

If we are willing to consider the teaching of these methods and techniques as necessary then we are faced with the necessity of curriculum options. Certainly some of the methods given above are suited to specific fields, and can be best taught when illustrated by applications in those fields.

In a field as broad as ours, it is necessary to have some division in order that the fundamental material may be suitably chosen and presented with a suitable viewpoint. In each area the fundamental knowledge must be restated, reoriented, and presented with the suitable viewpoint to be of use in connection with the fundamental methods and techniques of the area.

If we accept the definition that our "fundamentals" are composed of both knowledge and methods, then we seem led to the practical necessity for curriculum options. There seem to be at least four arguments to support the division of the field into at least the power and communications or electronics options.

Arguments in Favor of Options

The first argument in favor of options is simply that we have always had an option in electrical engineering. Webster defines an option as "that which is offered for choice" and up until possibly fifteen years ago we offered the student an option in machinery and he was at liberty to take it or leave it. If he left it he could still become a mechanical engineer or physicist, and a few schools were quite blunt in telling their students so.

A second argument is illustrated by the "reductio ad absurdum" method employed in the little problem concerning synchronous reactance and the magnetic field in the wave guide, wherein it was necessary to go so far back into fundamentals that very little was left. In other words, to bring a man up to a suitably high technical level in any field requires specialization and the learning of special *methods* inherent to that field, although not necessarily the learning of special fundamental knowledge. The general technical level in electrical engineering has advanced very greatly in the last twenty years, and we find it necessary to carry our students up to that higher level if they are to be able to continue to grow in the field after graduation.

It is also possible to teach the use and understanding of fundamentals through applications of those same fundamentals. A good student given Maxwell's equations can find it possible to solve a great many field problems sent his way. A poor student must be shown how to apply these equations. To many people Maxwell's equations mean very little in themselves. After being shown how to use them they become very valuable tools and in their use we learn to further understand and appreciate the original equations. Thus the teaching of the fundamentals becomes improved through the choice of proper applications.

A fourth reason for options may at first hand appear trivial, but to anyone who has taught service courses, or who has taught machinery to electronics men, it is very definitely not trivial. This is a matter of student motivation—the driving force which makes a student want to learn and to understand the material being presented in the course. Good teachers can frequently supply this in even the most uninteresting courses, but a poor teacher cannot, and thus anything we can do to aid will be an improvement in the student learning process. An electronics student is interested in matters associated with electronics. He is not interested in the details of the design of a synchronous machine. He will study harder on an

electronics problem whereas his machinery books will be pushed aside. A power student is interested in machinery or in power transmission, and understanding of the mathematics of modulation means little to him.

There is a danger present in the use of options if carried to such a point of specialization as to seriously limit the area of training of the student. We cannot know in what field a graduate may work five, ten, or twenty years after graduation, and rarely does the student have any firm expectations in this direction. In fact it can be said that ten years after graduation the type of product manufactured by his company will be of little importance to him, and that the really important factors at that time will be the general business policies of the company with which he is associated, and the opportunities to grow and advance which are inherent in his position.

Thus a desirable statement of policy on options seems to be—A minimum number of options is desirable, but the material chosen for any option should only be so narrow as to keep the student happy, and broad enough that there should be no damage to his education.

In Memoriam

Charles Ellison MacQuigg

Charles Ellison MacQuigg, past President of the ASEE and Dean of the College of Engineering at Ohio State University, died on April 24, 1952, in University Hospital, Columbus, Ohio.

Dean MacQuigg was born in Ironton, Ohio, on January 19, 1885. He graduated from Ohio State University in 1909 with a degree in Mining Engineering. He was awarded the Doctor of Engineering Degree by Clarkson College of Technology in 1946. He served as an engineer for the Sante Fe Railway Company and the Anaconda Copper Mining Company, 1909–1912. He was head of the Metallurgy Department of Pennsylvania State College, 1912–1917. From 1917 to 1919 he was Captain, Ordnance Department, U. S. Army. During World War II he was a Lieut. Col. in Ordnance Reserve. He was affiliated with the Union Carbide and Carbon Research Laboratories, Niagara Falls and Long Island City, New York, 1919–1937.

He became Dean of the College of Engineering at Ohio State University on July 1, 1937 and Director of the Ohio State University's Engineering Experiment Station. He was president of the American Society for Engineering Education, 1947–1948, and a member of the executive committee of the Engineering Division of the Association of Land Grant Colleges and Universities. He also had been a member of the National Research Council, and was currently a member of the Newcomen Society of England, Sigma Xi, Tau Beta Pi, AIMME, ASM and AAAS. He was a Fellow of the Ohio Academy of Science and a recipient of the James Turner Morehead Medal of the International Acetylene Association. He was a trustee of the Orton Foundation and a member of the board of directors and executive committee of the Ohio State University Research Foundation.

President Howard L. Bevis of the Ohio State University described Dean MacQuigg as follows:

"No man was more loved by students, no man more respected by the entire faculty. He was tireless in service. He gave himself without reserve to every cause in which he could be of practical help. He was a Christian gentleman who served science with distinction."

Dean MacQuigg is survived by his wife and three sons: Dr. Rodger E. MacQuigg, M.D., a surgeon, of Albuquerque, New Mexico; Major David E. MacQuigg, M.D. of the U. S. Army at Ft. Riley, Kans.; and Charles H. MacQuigg of Dallas, Texas.

A Philosophy of the Science of Graphics

By JOHN T. RULE

Professor and Head, Section of Graphics, Massachusetts Institute of Technology

This paper was written to be delivered to teachers of engineering drawing and descriptive geometry. Its entire intent was to stimulate interest in, and enthusiasm for, the comparatively undeveloped field of pure mathematical graphics. To the rigorous mathematician it will appear loosely written and will certainly raise a host of unanswered questions. I make no apologies for this for I believe the core notion of a science of graphics is a valid, though vaguely realized one. The prime business of the moment is the recognition of the problem.

It is my firm conviction that the science of graphics is an unrecognized science which offers the creative mind a tremendous challenge in a relatively unexplored world. This is the theme I wish to develop by offering a tentative, usable definition and in its light sketching a few of the possibilities.

Undoubtedly mathematics started with counting. As a matter of fact, to most human beings that is all that mathematics ever is, for the normal layman never needs anything but arithmetic, which is the science of counting. It involves a number system divided into units—one, two, three, etc. It thus has inherent in its structure the process of proceeding by steps. By developing fractions and decimals the steps are made as small as desired but remain steps, nevertheless. Thus 3.1416 represents pi to the nearest step when the steps are 1/10,000 of a unit. 3.14159 represents pi to the nearest step when the steps are 1/100,000 of a unit. Arithmetic is thus discontinuous in nature.

At some point in history geometry began to develop as the mathematics of space relations. Originally it was probably a practical business. It was lifted into the realm of consistent theory by Euclid and his school. Now, curiously enough, Euclid founded the science of graphics on the one hand and did it a profound disservice on the other. Perhaps he recognized the discontinuous, step-nature of arithmetic as opposed to the continuous nature of geometry and wished not to contaminate the latter when he restricted all constructional geometry to the use of the unmarked straightedge and compass. Whatever his reasons, he achieved two things. First, he barred the use of other curves than the circle since such curves were obtained by finding a limited number of points and fairing between these, which was not theoretically acceptable. Thus we still say we cannot trisect an angle. Second, in barring the marked ruler he barred the graphical device for converting lengths into the number system. He thus fixed the space nature of geometry by eliminating its calculational possibilities and in addition put a psychological barrier in the way of converting it into pure symbolism, which is the soul of the science of graphics.

That Euclid's straight-edge and compass restriction is an artificial one became apparent when the Italian mathematician Mascheroni showed that all the constructions possible with a ruler and compass alone may be made with the compass alone (provided that a straight line is thought of as given by two points. We cannot draw the line but we can find where it would intersect

another line or a circle, if it were drawn). Later Jacob Steiner showed that all these constructions are possible with a straightedge alone provided that a single fixed circle and its center are given.

Nature is Unruly

Thus we had until Newton's time a counting mathematics and a space mathematics. Unfortunately nature is a very unruly damsel. She knows nothing of counting which is a pure product of the human mind. Furthermore, she has a passion for the continuous as she, herself, is in a state of continuous change. Time and distance are continuous. Mass is effectively continuous above the atomic level. Thus a pure counting mathematics no longer sufficed as soon as we really seriously attempted to describe nature mathematically. Leibnitz and Newton enmeshed the continuous in mathematical symbolism by developing the calculus. The theory of limits bridged the gap. From our point of view it is noteworthy that this was done by converting the symbolism of counting mathematics into functional mathematics.

Thus, today, we have an extremely powerful equational, functional mathematics for dealing with physical reality. In many instances, however, it is very cumbersome. Furthermore it almost never exactly fits the facts. I want to emphasize this point. Equations are abstracted laws involving an artificially limited number of variables. However the physical universe refuses to conform to simple classical rules. A falling body falls according to the well-known formula only when we make very artificial assumptions, neglecting air resistance, variations in air density, etc. Thus we capture fundamental portions of nature in our equational world only by greatly oversimplifying the natural phenomena involved.

We cannot always do this. For instance, the resistance of a boat hull in moving through water, or of an airplane fuselage in moving through air depends on so complicated a set of factors that we measure these forces in model towing tanks or wind tunnels and make little claim to being able to predict them mathematically.

The basic trouble here is that we are substantially lacking one whole branch of mathematics, a branch that can describe completely by symbolic means physical phenomena far more complex than equational mathematics can. This branch of mathematics is the science of graphics, the nature of which has never been fully understood because of the wet blanket of Euclidean notions and the great success of equational mathematics and, in addition, because of its lack of oral quality.

The latter is a crucial factor. When I write 6 and say "6" I have a one-to-one correspondence between the written symbol and the spoken symbol. When I draw a line ———— I cannot talk about the magnitude it symbolizes until I convert it into the number system.

In order to define the science of graphics we must look more closely at symbols. Take the concept of time. Equationally we say, let "t" represent time. t can have any numerical value we choose. Graphically we say let this straight line represent time, and the line can have any length we choose. In each instance we are tied to a unit of some sort. A time of 100 or a time of the length of this line ———— has no meaning until we say in the first instance one shall be an hour and in the second instance this length —— shall be an hour.

Note that in both instances we are employing pure symbols, one as legitimate as the other. In the second instance, note that we have completely broken with Euclidean geometry for we are using lines as pure symbols for something else and are not tying them to space geometry.

Rectangular Coordinate System

It is important here to note that Descartes tied the space world of geometry to the world of numbers by

means of a rectangular coordinate system. It was basically a space describing system and did not contain the notion of lines as symbols until someone took the next step by assigning time, or the like, to one axis instead of distance. Cartesian coordinates like Euclidean constructive restrictions have been a bar to our understanding of the true nature of graphics. We shall come back to this later when discussing coordinate systems.

With the use of the line as a symbol of something else we establish the science of graphics. We may now define graphics tentatively, for our purpose here, as the use of geometric entities as mathematical symbols for manipulative and predictive purposes. The science of graphics is the science of performing by means of geometric symbols the same operations that can be performed by numerical, algebraic symbols.

The science of graphics is a full-fledged science of the continuous. In certain ways it has some remarkable advantages over equational mathematics. First, lines are continuous and numbers are not. Nature, herself, is fundamentally graphical. The first thing we do in collecting data is to use some form of conversion device for converting the continuous, graphical character of nature into the discontinuous number system. The three great conversion devices are the clock for converting time, the balance for converting mass, and the measuring stick for converting distance. Such conversions mean that in every physical problem except those involving pure counting there is no such thing as absolute accuracy, for the continuous character of nature can be read only to the nearest step in the number system.

Second, and of profound importance, we can symbolize graphically much more complex phenomena than we can symbolize equationally and we can handle successfully many more variables.

In many respects equational mathematics has great advantages over graphics. Thus in the last analysis some things can be done better graphically, some equationally, and a great many by a combination of the two. We cannot, however, fully capitalize on the possibilities until we fully develop the science of graphics.

The task before us then is to establish a set of graphical manipulations which are the analogs, or the equivalents of, numerical, algebraic, and analytic manipulations. Our first job is to develop a consistent, unified theory which will enable us to perform any mathematical process graphically, to demonstrate that the possibility exists that anything that can be done with equational mathematics can be done graphically and that in a very real sense the two are partners in the mathematical world. At the moment we can only begin this. Its full development is the great challenge. I am going to pick one or two arbitrary examples.

Graphical addition and subtraction are obvoius. So, as our first example we will examine multiplication. Suppose we want to multiply this length a

by this length b in these units 1 .

We'll call them a, b, and 1 (note the necessity of using letter symbols for oral purposes). If I draw two similar triangles, Fig. 1(A), it follows that $a/1 = x/b$ or $x = ab$. Superimposing these, I can lay out a and b at right angles for convenience, Fig. 1(B). I then mark 1 on the b axis, draw from a to 1 and draw a parallel from b to obtain x, the product of a and b, on the a axis.

Examples

Now we can take an example. We wish to multiply the a and b curves of Fig. 1(C) together. We draw a number of ordinates and mark the "a's" and "b's" and lay them out from "0" on the proper axis, paying attention to direction (sign). Next we draw the family of lines from the "a" points to 1 and draw parallels from the proper "b" points to obtain our required products. The process is shown for a_2 and b_2 and for a_3 and

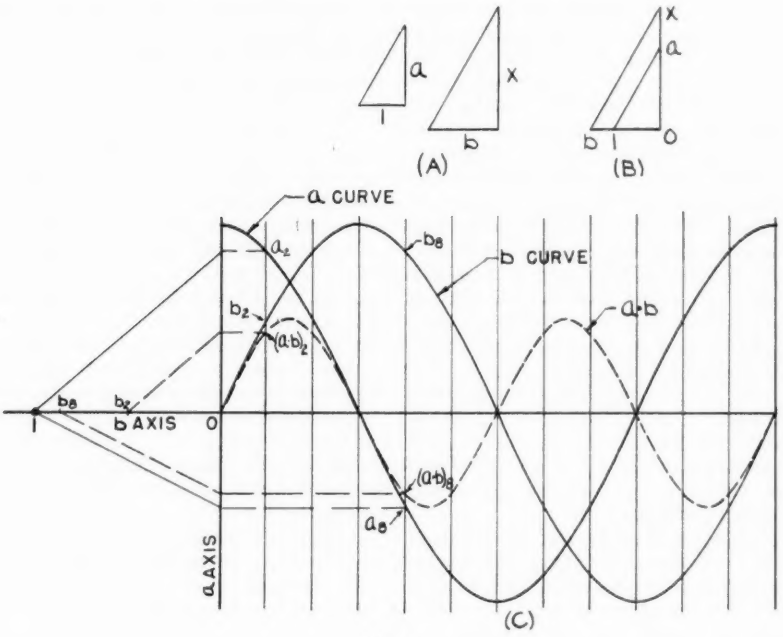


FIG. 1.

b_8 in the figure. We then distribute our products to the proper ordinates and draw a curve through the points. We have now multiplied our two original curves together. Now if we wish to convert this into equational mathematics the two curves are sin θ and cos θ. You will note that the product curve has half the height and twice the frequency and thus is $\frac{\sin 2\theta}{2}$. Thus $\sin\theta \cos\theta = \frac{\sin 2\theta}{2}$.

Some comments on the above example are necessary. First we have divorced ourselves from the notion of area—the Euclidean meaning of multiplication. Second, I have used a cartesian coordinate system only in order to make a recognized conversion between the equational and the graphical systems. Third, the inevitable question arises concerning accuracy, in that the two original curves will not exactly fit the theoretically perfect curves for sin θ and cos θ. It is not contended that they do. The two given curves multiplied together yield the third curve. If they are not the curves for sin θ and cos θ then the equational mathematician cannot multiply them together at all for he cannot fit equations to them. Yet they can be multiplied graphically *whatever they are*. It is equational methods that are in difficulty, not graphical. Fourth, this does not constitute a proof that $2 \sin\theta \cos\theta = \sin 2\theta$. It does show the pattern of correlation between the two systems.

In similar manner we can perform division. If we interchange the positions of "1" and "a" and proceed as before then x becomes $\frac{b}{a}$. If you care to perform this by dividing sin θ by cos θ you will find the result is tan θ.

Simultaneous Linear Equations

Now let's step up the line a little and consider the matter of simultaneous linear equations. All of you can solve two equations in two unknowns by plotting in cartesian coordinates. All of you can solve three equations in three unknowns by considering each equation a plane and finding the point of intersection of the three planes by descriptive geometry. In both instances you have employed cartesian coordinates and used a space analog of the equations—2 lines in a plane intersect in a point, 3 planes intersect in a point in space. Let's free ourselves from this basic Euclidean concept and look at a method which will solve n equations with n unknowns. (This method is adapted from "Graphical Methods" by Carl Runge, Columbia University Press, 1912.)

We'll take two simple equations for illustrative purposes:

$$3x + 5y + 4 = 0,$$
$$2x + y + 5 = 0.$$

We draw a line (Fig. 2) and lay out on it each of the three coefficients as a length from 0 (the coefficient of x will be called a, of y, b, and the constant c). We draw a second line parallel to the first and do the same for the second equation. I've reversed the direction, but that is of no importance. These marked lines are the graphical equations. We then draw the lines connecting the 0's, the a's, b's and c's. Now, any line parallel to our original line will cut the lines for a, b, and c in points which establish a graphical equation which will be satisfied by the same roots as the two original equations. Consequently we draw two lines, one through the point where the a line crosses the 0 line and one through the point where the b line crosses the 0 line. I thus obtain one graphical equation without a and one without b. Converting these from the graphical I obtain the two equations:

$$by - c = 0 \quad \text{or} \quad y = \frac{c}{b},$$

$$ax + c = 0 \quad \text{or} \quad x = -\frac{c}{a}.$$

Since these are scalable ratios I convert into the number system and find that $y = 1$ and $x = -3$ which are the required roots.

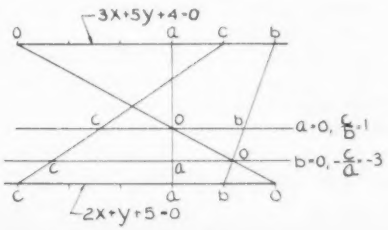


FIG. 2.

We can extend this process to three simultaneous linear equations having coefficients a, b, c, and d by eliminating a from any two pairs and obtaining two new equations in b, c, and d. We then operate on these two as above to obtain our roots. This process can be increased to include n equations in n unknowns.

The solutions of such simultaneous equations might be needed for our old friend the Wheatstone Bridge. The question being what equivalent single resistance may be substituted for the network so that the current passing through will be fooled and not know the difference.

Electrical Networks

We can extend this into a tougher problem in electrical networks. Instead of simple resistances in each branch of the bridge circuit, suppose that there is a combination of inductance and capacitance and resistance. For a given applied alternating voltage of a certain amplitude and frequency what is the resulting alternating current amplitude and phase? Now, an impedance is a complex number so that our simultaneous equations now have complex coefficients which we must graph as vectors in the complex plane. However, the elimination proceeds in a graphical way analo-

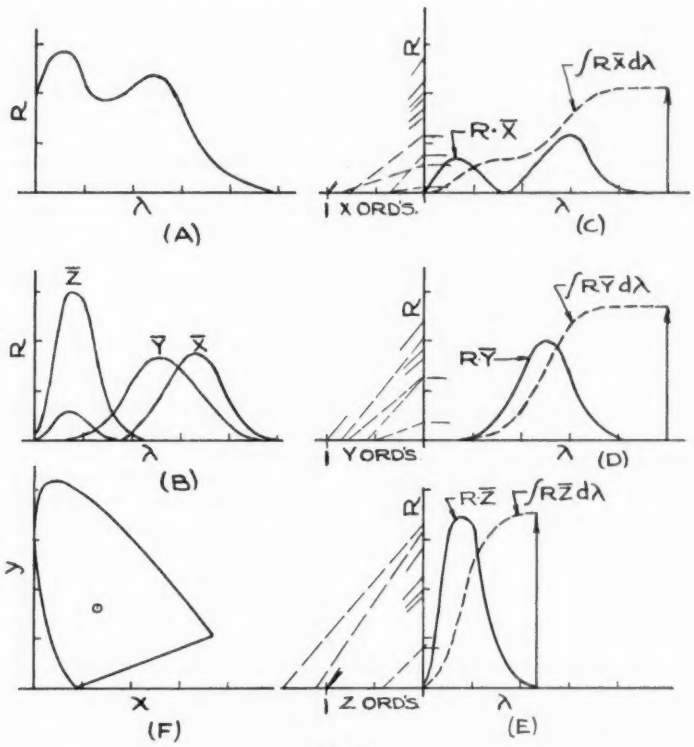


FIG. 3.

gous to the above and the solution of the equations may be found. I won't do it here. I bring in this application to suggest the intriguing possibilities of a comprehensive graphical theory for networks.

There is a similar sort of process for obtaining the roots of higher power equations which I won't go into here.

Next in line are graphical integration and differentiation. You all know that we can do this with a great deal of accuracy and rapidity.

Now, I want to take a physical example of the use of a combination of these processes. In many fields of modern science the simple parabolas and hyperbolas and linear differential equations that used to describe reality are being replaced by empirical curves and functions that more nearly describe the behavior of our universe. I am choosing as an example the tristimulus color problem for it involves curves to which equations cannot be fitted so that a laborious numerical process is usually followed.

Fig. 3(A) shows an assumed curve of reflectance of a dye pigment under a given light source.

It also shows the $\bar{X}$, $\bar{Y}$, $\bar{Z}$ curves, Fig. 3(B), the response curves of the eye to three standard primary colors. Now the blue seen by the eye x will be

$$\int_0^\infty R\bar{X}\,d\lambda.$$

This is, of course, an impossible equational operation as we cannot find any

equation to integrate. Our first job is to multiply R by $\bar{X}$, Fig. 3(C). We have already seen how to multiply two curves together. This yields the product $\bar{X}R$. We now integrate this from 0 to ∞ and get the x vector. We repeat this process for $\bar{Y}$ and $\bar{Z}$ and get the y and z vectors, Fig. 3(D and E)—a multiplication and an integration in each instance performed very rapidly. Since the sum of the three is unity we can mark the color on the standard tristimulus chart Fig. 3(F).

I want you to note that in solving this very complex problem we have never once left the graphical world. We've operated completely in geometric symbols without ever employing a number. Furthermore, we have followed the complex pattern of physical reality without employing oversimplifications for the sake of getting equations which we can manipulate.

Coordinate Systems

At this point I think you can see the beginnings of a unified attack on graphical procedures. I want to talk a minute or two on coordinate systems for our persistence in using cartesian coordinates highlights the difficulty of breaking our thinking about graphics away from space concepts. If we are going to be successful in this area we must think of lines as pure symbols and operate on them with freedom. We can use any arbitrary coordinate system we choose so long as it is fruitful. We can use line coordinates or point coordinates or any distorted field of coordinates. A coordinate system is basically a conversion device between the two mathematical systems. Since a combination of the two systems is most fruitful in many problems, the free use of coordinate systems without respect to a space analog becomes a very important factor.

You will find that all mathematicians say that $x^2 + y^2 = R^2$ is the equation of a circle. This simply is not true in any broad sense. It is true *if* cartesian coordinates are used but we can show a coordinate system in which it is an ellipse or some other conic.

An interesting problem is that of taking a family of curved lines and developing a coordinate system in which a maximum number of the family are rectified. We can show that this can always be done for 3 such lines, and I suspect a solution exists for 4, but we've been unable to find it.

Another interesting procedure is to project cartesian coordinates by central projection into a system containing two vanishing points. Note that we then can plot any curve out to infinity which has some useful possibilities. I am convinced that we have only begun to examine the coordinate system problem.

Conclusion

In closing I want to point out that we are dealing with a pure science and that our focus of attention should be on pure research without hampering ourselves with the notion of applicability. We have only barely scratched the surface of this science. The mathematician does research for the sake of discovery alone. Applications generally follow discovery. We should treat the science of graphics in the same way and never tolerate the question, "what good is it?". No science of any dignity ever tied itself to the utilitarian.

It seems to me that the coordinated type of attack that I've tried to outline contains the true future of the science of graphics.

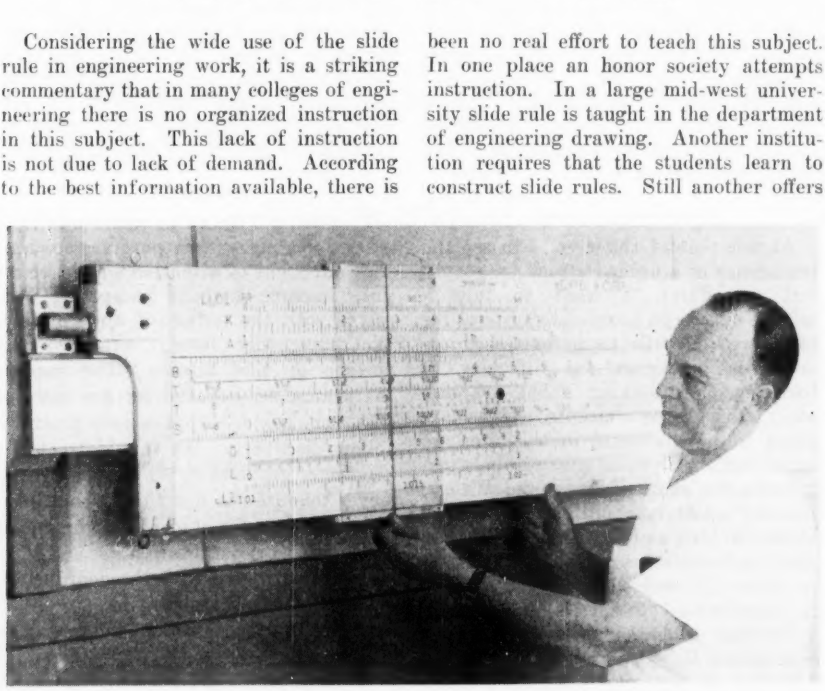
I want to acknowledge my indebtedness to two of my colleagues—to Mr. John F. Twigg for the example on graphical multiplication and to Mr. Steven A. Coons as a major contributor of the philosophic ideas and the work on coordinate systems.

Slide Rule Instruction in Technical Schools

By HERMAN K. FULMER

Professor of Mathematics, Georgia Institute of Technology

Considering the wide use of the slide rule in engineering work, it is a striking commentary that in many colleges of engineering there is no organized instruction in this subject. This lack of instruction is not due to lack of demand. According to the best information available, there is a steady demand for slide rule instruction among undergraduates generally. This demand is further attested by the continued publication of books, instruction sheets, and pamphlets on the various applications of the slide rule. But taking engineering colleges as a group, there has been no real effort to teach this subject. In one place an honor society attempts instruction. In a large mid-west university slide rule is taught in the department of engineering drawing. Another institution requires that the students learn to construct slide rules. Still another offers free group instruction on demand. One of the most serious objections to haphazard instruction is that frequently the best methods are never learned and that, due to the tendency to stick to what is first learned, the student goes through life doing unnecessary work.



SLIDE RULE INSTRUCTION IN TECHNICAL SCHOOLS

In order to meet the demand mentioned above, two years ago the Department of Mathematics of the Georgia Institute of Technology incorporated use of the log log duplex decitrig slide rule as an integral part of the course in trigonometry. By this plan, really borrowed from North Carolina State College, slide rule is not taught as a topic. Rather, it is taught in connection with other topics where the correlation is easy and natural. This method has the very great practical advantage of not trying to cram on all the various applications at once. Early in the quarter, students in trigonometry are invited to a movie (cooperation of Keuffel & Esser) showing basic slide rule operations. Experience shows that this movie aids considerably. Following this, and early in the course, applied problems involving multiplication and division are taught. Along with instruction on use of the tables of natural functions, their use with slide rule is explained. Many right triangles are solved by slide rule. Still later in the course where fractional powers are taught by the use of logarithms, the use of the slide rule for this work is also explained. The rule is also used in the solution of exponential equations like $2^x = 7$. Finally, in the solution of oblique triangles we stress the slide rule.

It is interesting to note that instruction in slide rule seems not to shorten the time allotted to other topics. Rather the speed and simplicity with which many problems may be solved more than compensate for the time spent in learning. The department owns 6 master demonstration rules which are mounted (see photograph) as standard equipment in class rooms. We are indebted to the School of Mechanical Engineering for this simple and permanent solution of the old problem of how to change sides with these large rules. This mounting is not patented and could be used any where. The rules are mounted along the side wall of the classroom, are always available, never in the way.

A recent survey shows that the students appreciate this instruction. We would welcome correspondence and suggestions toward improvement.

Sanitary Engineering Conference

A two-day conference on Sanitary Engineering Education sponsored by Committee 3 of the ASEE Civil Engineering Division, with the cooperation of the U. S. Public Health Service and the American Public Health Association, will be held at Dartmouth starting Saturday, June 21. The program of the conference is as follows:

Saturday, June 21

1:00 p.m.	Radiological Training
1:45	Field Training
3:15	Training Sanitary Engineers (panel discussion)

Sunday, June 22

9:30 a.m.	What is the Present Day Field of Sanitary Engineering?
10:30	Minimum Requirements for Sanitary Engineers
1:30 p.m.	Sanitary Engineering in the Smaller College
2:30	Graduate Program
4:00	Adjournment

Monday, June 23 Committee Reports

Arrangements for the conference are in charge of the following special committee:

Gilbert Dunstan, Chairman	Earnest Boyce
Jess C. Dietz, Co-chairman	E. S. Brown
Arthur P. Miller	William T. Ingram
Ellis S. Tisdale	E. J. Kilcawley

This committee is working in cooperation with Committee 3. Reservations for the conference should be made with Professor E. S. Brown of the Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire.

TIMELY TIPS

A Direct Development of the Polytropic Process

By E. J. WELLMAN

Instructor of Mechanical Engineering, Purdue University

In the presentation of reversible, non-flow processes for ideal gases in most thermodynamics texts, the position of the polytropic has appeared to the author to be incongruous. The constant pressure, constant volume, isothermal, and isentropic processes are naturally grouped because they are characterized by the constancy of a particular property. The polytropic equation $pv^n = C$ (a constant) appears to be simply a convenient mathematical formulation which has little physical significance, but which can be adjusted to fit each of the others by proper selection of the value of the exponent n.

A method of relating all of the above processes involves an entirely different approach which requires a fresh start.

Let us consider, for a non-flow, reversible process, the ratio of heat to work, dQ/dW. Let $dQ/dW = E$. Now if we restrict our analysis to those processes for which E is a constant, we may derive a $p - v$ relationship to satisfy this premise.

$$dQ = EdW,$$

or

$$dQ = Epdv.$$

From the First Law

$$dQ = du + pdv.$$

From Joule's Law

$$dQ = c_v dT + pdv.$$

Then

$$c_v dT + pdv = Epdv.$$

By differentiating $pv = RT$ we obtain

$$dT = \frac{pdv + vdp}{R}.$$

Then

$$\frac{c_v}{R}(pdv + vdp) = pdv\,(E - 1).$$

Using $c_v/R = 1/(k - 1)$ and re-arranging

$$vdp + pdv[k - E(k - 1)] = 0.$$

Now let $n = k - E(k - 1)$. Then

$$vdp + npdv = 0,$$

$$\frac{dp}{p} + n\frac{dv}{v} = 0,$$

which, when integrated, yields

$$pv^n = C.$$

Therefore this $p - v$ relationship characterizes the general process for which dQ/dW is a constant.

It may now be noted that for each of the other four processes described above dQ/dW is a constant. Hence each is a polytropic.

For each process the ratio E may be determined by separate calculation of work and heat by the usual methods. Then the proper exponent n may be determined from the above definition of n, i.e., $n = k - E(k - 1)$. The results of such determinations are listed below:

	E	n
Constant pressure	$k/(k-1)$	0
Constant volume	∞	$-\infty$
Isothermal	1	1
Isentropic	0	k

The utility of this analysis may be extended to obtain simple expressions for dQ, dW, and du usable for any of the processes discussed above.* Using only

* Since the equations are all given in terms of dT, the work and heat expressions become indeterminate for the isothermal process.

the First Law, and the basic premise that E is a constant, the following may be obtained in terms of n or E:

$$dQ = c_v \left(\frac{k - n}{1 - n} \right) dT$$

or

$$dQ = c_v \frac{E}{E - 1} dT,$$

$$dW = c_v \left(\frac{k - 1}{1 - n} \right) dT$$

or

$$dW = c_v \frac{1}{1 - E} dT,$$

$$du = c_v dT.$$

This method undoubtedly will not contribute to a better understanding of the four basic processes, but it does present a simple and logical definition of the polytropic process. It indicates, also, that the polytropic does not include all possible processes but has a very precise restriction. It also becomes easier to understand why the polytropic process has been utilized to attempt to describe some actual compression processes in which heat was not exactly that prescribed by the isothermal nor zero as required by the isentropic, but the heat does bear a fixed relation to the quantity of work.

The Third National Surveying Teacher's Conference

Sponsored by

Committee 8, Civil Engineering Division, ASEE

and

The University of Illinois

August 3–8, 1952

Camp Rabideau, Summer Surveying Camp of the University of Illinois, will be the scene of The Third National Surveying Teacher's Conference, August 3–8, 1952. Situated in the Chippewa National Forest of Northern Minnesota and in an area famous for its lakes and Paul Bunyan lore, Camp Rabideau with an unparalleled physical plant and pleasant woodland environment offers excellent facilities for conference activities and communal living.

The Illinois Surveying Camp is located on federally-owned forest land in Beltrami County about 35 miles northeast of Bemidji. Deer and small game abound in the heavy stand of second-growth timber that covers this region. Daily rail and bus service is available from Minneapolis to the village of Blackduck which is 6 miles north of the camp. Good highways approach the area from all directions.

For further information address Brother B. Austin Barry, F. S. C., Chairman Committee 8, Civil Engineering Division, ASEE, Manhattan College, New York 71, N. Y.

Dining and sleeping accommodations will be furnished at a cost of about $25 per person for the six-day period. A reduced rate will be made for children. Reservations should be made with Dr. M. O. Schmidt, Director of Camp Rabideau, Surveying Building, University of Illinois, Urbana, Illinois.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State College	April 18–19, 1952	E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Villanova College	May 10, 1952	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oncken, Jr., Bureau of Ordnance
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Washington	April 25–26, 1952	T. H. Campbell, University of Washington
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	S. F. Duncan, University of Southern California
Rocky Mountain	University of Wyoming	April 19, 1952	E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952	R. L. Sumwalt, University of South Carolina
Southwestern	University of Houston	April 25 & 26, 1952	H. P. Adams, Oklahoma A. & M. College
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ABEGG, MARTIN G., Assistant Professor of Civil Engineering, Bradley University, Peoria, Illinois. H. Blichensderfer, R. E. Gibbs.

ANDERSON, HENRY C., Instructor in Mechanic Arts, Lincoln University, Jefferson City, Mo. C. B. Taylor, W. Jackson.

ANDERSON, WARREN R., Associate Professor of Electrical Engineering, California State Polytechnic Institute, San Luis Obispo, Calif. C. E. Knott, E. C. Glover.

AYRES, G. H., Professor of Chemistry, University of Texas, Austin, Texas. A. B. Bronwell, S. C. Hollister.

BAKER, BURTON C., Supervisor—Technical Placement, Minnesota Mining & Manufacturing Company, St. Paul 6, Minn. E. W. Johnson, W. W. Burton.

BALISE, PETER L., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. J. B. Morrison, R. W. Crain.

BENDER, LUKE R., Assistant Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pa. W. D. Garman, D. W. Griffith.

BENTLEY, WILSON J., Associate Professor of Engr. and Mgmt., Oklahoma A. & M. College, Stillwater, Okla. H. G. Thuesen, M. R. Lohmann.

BROWN, CHARLES L., Associate Professor of Mechanical Engineering, Purdue University, Lafayette, Ind. O. W. Witzell, D. S. Clark.

BUCKNER, WILLIAM N., Principal, Armstrong High School, Washington, D. C. L. K. Downing, J. C. Webster.

BUXTON, ALBERT C., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. C. W. Ricker, J. A. Cronvich.

CHACEY, LLOYD A., Executive Secretary, The Ohio Society of Professional Engineers, Columbus 15, Ohio. C. E. MacQuigg, W. D. Turnbull.

CLEMMER, GEORGE H., Asst. Mgr., Goodyear Ind. Univ., Goodyear Tire & Rubber, Barberton, Ohio. F. S. Griffin, E. R. Wilson.

CLOUGH, RAY W., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. J. B. Franzini, E. P. Popov.

COWLES, RALPH G., Instructor in Humanistic-Social Studies, University of Washington, Seattle, Wash. S. W. Chapman, J. W. Souther.

DAVIDSON, SIDNEY, Assistant Professor of Industrial Engineering and Accounting, Johns Hopkins University, Baltimore, Md. R. H. Roy, W. B. Kouwenhoven.

DAVIS, HOWARD P., Associate Professor of Mechanical Engineering, University of Wyoming, Laramie, Wyo. E. J. Lindahl, H. T. Person.

DEGROFF, HAROLD M., Associate Professor of Aeronautics, Purdue University, Lafayette, Ind. M. U. Clauser, E. F. Bruhn.

DUBBE, EVERETTE C., Assistant Professor of Electrical Engineering, West Virginia University, Morgantown, W. Va. E. C. Jones, C. B. Seibert.

DUNCAN, ACHESON J., Associate Professor of Industrial Engineering and Statistics, Johns Hopkins University, Baltimore, Md. R. H. Roy, W. B. Kouwenhoven.

ESMAY, MERLE L., Associate Professor of Agricultural Engineering, University of Missouri, Columbia, Mo. M. M. Jones, J. C. Wooley.

FELLING, WILLIAM E., Instructor in Aeronautical Engineering, St. Louis University, East St. Louis, Illinois. R. A. Killoren, A. B. Bronwell.

FITZGERALD, ARTHUR E., Associate Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. C. E. Tucker, H. L. Hazen.

HITE, SAM C., Assistant Professor of Chemical Engineering, Purdue University, Lafayette, Ind. J. L. Bray, R. N. Shreve.

HUDSPETH, E. L., Professor of Physics, University of Texas, Austin, Texas. A. B. Bronwell, S. C. Hollister.

HUGHEL, THOMAS J., Assistant Professor of Metallurgical Engineering, Purdue University, Lafayette, Ind. J. L. Bray, G. W. Sherman, Jr.

KILBRIDGE, MAURICE D., Assistant Professor of Industrial Engineering, Illinois Institute of Technology, Chicago 16, Ill. P. Davis, B. A. Fisher.

LEACH, WILLIAM J., Administrative Assistant to the Dean and Instructor in Engineering, University of Houston, Houston, Tex. T. N. Whitaker, M. L. Ray.

LOVELL, CHARLES W., JR., Instructor-Research Engr., Civil Engineering, Purdue University, Lafayette, Ind. R. B. Wiley, K. B. Woods.

MALLORY, WARREN M., Assistant Professor of Electrical Engineering, University of Wyoming, Laramie, Wyo. E. J. Lindahl, H. T. Person.

MCCLELLAND, HENRY A., Instructor, Goodyear Ind. University, Goodyear Tire & Rubber Co., Akron, Ohio. F. S. Griffin, E. R. Wilson.

MILLS, ROSCOE E., Professor of Engineering Materials, Purdue University, Lafayette, Ind. P. E. Soneson, F. W. Stubbs, Jr.

MORRILL, ALLEN C., Professor and Head, Language Dept., Michigan College of Mining and Technology, Houghton, Mich. P. V. Anderson, W. Harrington.

PLUM, WILLIAM B., Director of Education, U. S. Naval Ordnance Test Station, China Lake, California. L. M. K. Boelter, A. S. Levens.

REGENBRECHT, DOUGLAS E., Instructor in Mechanical Engineering, Purdue University, Lafayette, Indiana. O. W. Witzell, D. S. Clark.

REITAN, DANIEL K., Instructor in Electrical Engineering, University of Wisconsin, Madison, Wis. T. J. Higgins, J. J. Skiles.

ROPPOLO, JOSEPH P., Assistant Professor of English, Tulane University, New Orleans, La. A. B. Bronwell, S. C. Hollister.

SCORDELIS, ALEXANDER C., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. J. B. Franzini, E. P. Popov.

SIMPSON, HAROLD B., Educational and Training Specialist, U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md. D. E. Starnes, R. J. Seeger.

SPENCE, ROBERT A., Lecturer, Civil Engineering, City College of New York, New York, N. Y. H. G. Lorsch, J. A. Olsen.

THOMA, EDWARD C., Associate Professor of Civil Engineering, Purdue University, Lafayette, Ind. B. H. Petty, K. B. Woods.

WEEKS, O. D., Professor of Government, University of Texas, Austin, Texas. A. B. Bronwell, S. C. Hollister.

WEHMANEN, ROY W., Assistant Professor of Engineering Drawing, University of Dayton, Dayton, Ohio. J. A. Wehrle, A. R. Weber.

WOOD, HAROLD S., Assistant Professor of Aeronautical Administration, St. Louis University, East St. Louis, Ill. N. C. Beck, V. J. Blum.

427 new members this year

English Division Summer School

Theme: Orienting the New English Teacher in the Engineering School.

Session I, June 20, 9:00 A.M. Topic: The English Teacher in the Engineering School.

Session II, June 20, 2:00 P.M. Topic: Has Freshman Composition Failed?

Session III, June 21, 9:00. A.M. Topic: Standards of Correctness: Prescriptive vs. Descriptive Grammar.

Session IV, June 21, 2:00 P.M. Topic: Articulation of High-School and College English.

Session V, June 22, 2:00 P.M. Topic: What Literature to Teach and How to Teach It.

The 1951 ASEE Engineering Education Mission to Japan

By H. L. HAZEN

Professor, Head, Department of Electrical Engineering, Massachusetts Institute of Technology

As a result of an invitation to the American Society for Engineering Education on behalf of the Supreme Commander for the Allied Powers in Tokyo, a mission of fifteen of its members spent July and August 1951 in Japan conferring with Japanese engineering educators on all phases of engineering education. Over one thousand Japanese educators and industrialists participated in the Institute for Engineering Education, which was the name of the Japanese organization for implementing the work of the Mission. Mission members returned to this country with a sense of accomplishment, of having achieved a substantial meeting of minds, and of having contributed ideas that can help Japan in solving some of her serious problems. This paper gives highlights of the Mission's work and activities, including an appendix with the essential organizational facts.

Reasons for Mission

Why send an Engineering Education Mission to Japan? Our great national interest in Japan, only recently an enemy nation, is based on our desire that she be one of the family of free nations rather than one of the slave nations. Japan occupies an important position geographically and culturally in the East. Our country has expended vast sums since the war to help Japan to become democratic in her institutions and thinking and to approach economic self-sufficiency. Educational institutions and methods of course play a dominant part in any such reconstruction; hence the significance of the several previous educational missions to Japan. The particular significance of engineering education grows out of Japan's present circumstances.

Japan has a serious basic economic problem. She is a nation of 83 million people, living in an area which is comparable with California's, and of which only 15 to 20 per cent is arable. With most intensive cultivation, this land yields only 80 per cent of her essential food. For the remainder, Japan can exchange in trade only the labor, the energy of rivers and of some coal, and the ideas that she is able to add to imported raw materials to produce exportable manufactured goods. Science and technology are thus of great importance to Japan, and this fact in turn places a large responsibility on her engineering schools. If she is to develop and produce superior products for trade, Japan needs many good engineering graduates for her industry.

Japan has over forty engineering schools, which have produced some notable men and work in past years. However, they are now suffering from poverty and from a decade or more of virtual isolation from the rest of the world. They operate with many principles and practices that we in the United States would find restraining, ineffectual, and unresponsive to the needs of engineering education as we see them. Not for many decades have they felt the influence of engineering education in the United States. Thus,

Major General W. F. Marquat was led to write to former ASEE President Thorndike Saville in part, "Preliminary discussions with other sections (of SCAP) and with Japanese educators and engineers lead us to feel that a great deal of good could be accomplished by bringing to Japan a group of American engineers who could discuss with their Japanese counterparts some of the problems which are now facing professors of engineering in Japanese educational institutions." Actually this quotation, with a few subsequent suggestions, constituted the principal instruction to the Mission.

Planning the Program

The Mission as a whole was in Japan seven weeks beginning July 6. One week was devoted to orientation and joint planning with the Japanese Executive Committee of the Institute for Engineering Education; five weeks to working sessions in Tokyo, Kyoto, Nagoya, Fukuoka, Sendai, and Sapporo; and one week in Tokyo preparing the final report, which was submitted on the morning of the day of departure, August 26.

That these seven weeks were packed with activity is indicated by the following statistics. Jointly-planned general sessions and panel discussions on the broader phases of engineering education and administration totaled 114, while 72 group conferences considered particular branches of engineering. A fruitful exchange of ideas came from 34 conferences with exclusively junior-staff and graduate-student groups. At least 1500 Japanese individuals attended one to several of these 220 meetings. Mission members gave 28 talks to professional society meetings and visited about 40 industrial plants and engineering works. Of the Mission's extracurricular activity, encouraged and implemented by SCAP as an important medium of preparation for effective work in Japanese environment, a few words appear subsequently.

That our Japanese counterparts were deeply and sincerely interested in studying and strengthening their engineering education was evident from the thoroughness and care with which they planned and executed their Institute for Engineering Education. Dr. Hiroshi Wada, Chairman of the Japanese Executive Committee, and his associates were highly and effectively co-operative from beginning to end. They accepted the proposal to use the panel and group discussion technique instead of formal lectures, although these were to them new procedures. They quickly learned to capitalize on these meeting techniques and prepared excellent and searching questions for discussion at panel and group meetings. Each meeting had a Japanese and an American co-chairman. The Mission members very soon found that real issues in educatinoal philosophy and methods became the center of attention and that the anticipated problem of establishing rapport between the oriental and the occidental mind in this field was largely nonexistent.

Language difference was of course an inconvenience, but not a real barrier. Care in screening interpretors paid high dividends, for through them was transacted most of the business of the entire Mission effort. Translation reduced the rate of expression of ideas by a factor of two or three to one. Against this, however, were the pressure and opportunity that translation time produced for sharpening up ideas and eliminating all but essential points. Also, since most Japanese participants understood some English, translation provided the emphasis of repetition. Furthermore, ideas seldom can be absorbed as rapidly as they can be expressed in a single language; hence, the loss in pace was probably more apparent than real in terms of significant ideas exchanged.

The real work of the Mission proved to be the conduct, jointly with the Japanese, of an extended series of symposia covering the broad subject of engineering schools and education. American ideas were emphasized as the Japanese were in general unfamiliar with these and wanted

to learn about them. The results of the Mission thus consist basically of new ideas and stimulus in the minds of men and are not susceptible of easy statement and demonstration. However, the scope of our discussions is sketched subsequently. One tangible result is the initial steps that are being taken toward the formation of a Japanese counterpart of our ASEE. Our fellow ASEE members are of course interested in engineering education in Japan. While critical examination and appraisal were not our main object, certain definite impressions were formed as follows.

Engineering Education in Japan

National universities, in general the most important, are closely controlled in budget, personnel appointments, and operations by the central government, severely restricting the autonomy and flexibility of operation of the individual university by our standards. Administrative posts are largely limited-term elective in character. Funds may be used only in accord with detailed original budget allocations. Virtual prohibition of personal income from consulting by faculty in government institutions greatly hinders industry-university relations, as does the strong emphasis on patents and trade secrets. Some research institutes, separate from but close to universities, in which faculty members work on industry-aided research partly bridge this gap between universities and industry.

Formal instruction is almost entirely by the lecture system without textbooks, problems, or homework. Laboratory equipment for instruction is mostly very old, though some laboratory programs appeared good. Graduates were criticized in general for being too exclusively theoretical, though we saw the beginnings of experimental ingenuity in some graduation thesis reseach. Very little graduate work as we know it is offered in Japan, the doctorate being essentially the certification of a thesis. Japanese universities, never affluent, are very poor financially today after a roughly 200 to 1 inflation since prewar. The effects are apparent. Professors spend 70 percent or more of their salaries for family food. Yet the spirit appears good. Private universities, some of which are important institutions, suffer more than the great tax-supported National (formerly Imperial) universities.

Since the early 1900's, European, and especially German, influence was dominant until the American occupation. Thus the pattern has been markedly different from that in the United States. Research rather than teaching-and-research is the commonly declared function of the university and its professors. A professorship is commonly regarded as a position of glorified authority which is relatively untempered by the qualities and ability of the incumbent professor.

While important work has come from such Japanese as Honda, Yagi, Okabe, Yukawa, and others, Japanese industry in general shows little influence of strong, original engineering. The ratio of engineers to total employees is a small fraction of the corresponding American figure. These facts and her efforts to industrialize rapidly make natural the close resemblance, and indeed often apparent identity between many Japanese products and western products.

In the universities, each "chair," consisting of a professor, two or more assistant professors, and a group of assistants, tends to be an independent and isolated unit of research and teaching, with little of the team spirit in any larger grouping that is so vital a part of our operations. Each institution tends to be highly self-sufficient. Intensive inbreeding of staff and students is regarded as a mark of quality. Apparently inter-institutional group discussions of engineering education occasioned by this Institute for Engineering Education were quite unprecedented as was the participation of industrial representatives.

Engineering libraries, woefully deficient in acquisitions since 1940, are much less used and useful than in the United States.

Dormitories and other student group living is virtually unknown in Japan, and the literal absence of any physical facilities for student study, at home or school, is a serious lack.

At the sub-professional level, the Semmon Gakko, equivalent of our post-high school technical institute, was abolished after the war in the attempt to provide more universities through upgrading of these Semmon Gakko to degree-granting institutions. This leaves a serious void in the technical education system.

Leading engineering educators in Japan, and these include men of real ability, are quite cognizant of many of these characteristics of Japanese engineering education. They apparently welcomed the Mission as an important means of presenting western methods and outlook to their many associates. That there was widespread and serious interest among them in engineering education problems and in our methods was clear from the many thoughtful and searching questions put to the Mission. While we covered our educational methods and philosophy thoroughly, we also stressed that they, the Japanese educators, should not copy, but must themselves think through their needs and aggressively develop methods answering these needs while making full use of all of the ideas available.

Although the Mission members went armed with detailed materials on American teaching methods in engineering, they quickly found that the Japanese were prepared to discuss matters of broad educational policy with insight and discernment. Several Japanese addresses at opening sessions pointed up pertinent problems. Discussions and questions prepared by the Japanese in advance of most sessions focussed subsequent discussion on issues important to them on which they desired the American point of view. Mission members were impressed with the basic similarity between many of the issues confronting engineering education in the two countries. On the other hand, the pattern of Japanese engineering education is essentially German and in many aspects is contrary to the spirit and methods in our country. Mission members used direct criticism sparingly. Rather they discussed the methods and point of view of our country with the reasons therefor, sometimes stating why under our conditions we should find a Japanese usage quite unsatisfactory. The accompanying "summary" from the Mission report presents the highlights of its conclusions.

One notable and not entirely expected characteristic of these discussions was the virtual unanimity of all Mission members, representing the greatest diversity among engineering schools over our country, on all important issues concerning engineering education. Methods of operation vary widely over our country, but statements of objectives, principles, policies, and even the spirit of these operations were surprisingly alike. No doubt the ASEE has been a powerful influence toward achieving this basic agreement as to what is important and good.

Topics of Discussion

The many sessions of the IFEE covered in some detail virtually the entire field of engineering education. Programs were evolved continuously as the sessions progressed by joint program committees. Specific topics at each session were introduced by the Japanese by well-thought-out and often searching presentations followed by definite questions. The over-all scope of program subject matter is suggested by the following partial list of subjects considered at the various sessions.

Undergraduate curriculum
- Time allocation to general education, science, common engineering, and major-field engineering.
- Technical level to be attained.

Teaching methods
- Lecture vs. discussion-recitation.
- Textbooks and homework.
- Co-operative courses.
- Laboratory methods.
- Importance of the library.

Students
- Selection and admission.
- Guidance.
- Academic standards and dismissals.
- Type of employment.
- Placement and salaries.
- Living arrangements.
- Costs.
- Student life.
- Extracurricular activities.

Graduate study and research
- Degrees and requirements for these degrees.
- Recognition by industry.
- Nature and level of work.
- Graduate researches.
- Fellowships, scholarships, and assistantships.
- Day and evening programs.

Faculty-student relations
- Attitudes.
- Spirit.
- Guidance.
- Counseling.

Faculty
- Selection.
- Basis for recognition and promotion.
- Tenure.
- Duties and responsibilities.
- Hierarchial relations or their absence.
- Responsibilities.
- Consulting privileges.
- Standard of living.
- Co-operation and team work.
- Place in the community.
- Place in their profession.

Organization and administration
- Institutional autonomy under the board of trustees.
- Career administrative officers.
- Faculty organization.
- Department unit.
- Sources of income.
- Junior college.

Industry-university relations
- Employment of graduates.
- Trustees from industry.
- Contract research.
- Patents and trade secrets.
- Co-operative courses.
- Grants and fellowships.
- Summer and sabbatical employment of faculty.
- Lecturers from industry.
- Visiting committees.
- Extension work.

ECPD and ASEE
- Relation to education and the profession.
- Functions.
- Accreditation.
- Procedures and methods of operation.

Problems peculiar to the educational reform in Japan under U. S. guidance.
- Lower terminal level for engineering students under the Japanese "New System."
- Loss of technical institute level of training.

Problems characteristic of individual branches of engineering
- Further discussions in group sessions by fields.

Among the team at least one and often many could speak to a subject from personal experience. Members rapidly became adept at organizing and giving terse verbal essays on very few minutes notice. Apparently our Japaneses associates were greatly impressed with the ability of Americans to do this and do it with assurance, poise, indeed finish, and in a voice that could be readily heard throughout a sizeable meeting hall. The obvious seriousness of interest of the Japanese in learning of our ways, evidenced by the quality and care with which they prepared for the meetings, their active discussions from the floor, and general attitude, made these sessions a challenge.

Report of the Mission

During the final week in Toyko a 100-page report with a 150-page appendix was prepared and officially submitted. It is essentially an essay on engineering education in the United States, which, being addressed in intent to Japanese engineering educators, reflects in its emphases the reactions of Mission members to the Japanese scene in education. This report, submitted to General Ridgway, was soon made available to the Japanese, who promptly began translating it into their language for wide distribution among those concerned with engineering education.

The summary appearing at the beginning of the report of the Mission is re-

produced verbatim as an accompanying paper.

In conclusion, a few impressions on the personal aspects of such a Mission are relevant. In auspices, as detailed in the appendix, this Mission was most fortunate. General Marquat gave it essentially *carte blanche* professionally. Travel and living arrangements (made by the Unitarian Service Committee under Army contract, and administered in Japan by Miss Dorothy E. Snavely of USC, Executive Officer of the Mission) were so well handled that they quickly became taken for granted. Thus the Mission worked under essentially ideal conditions—aside from heat somewhat worse than a Washington, D. C. summer, without air conditioning.

On the extracurricular side, regarded by SCAP as an important part of orientation to the Japanese environment, Mission members visited many places of cultural interest and natural beauty. They were honored guests at numerous teas and at official prefectural and city dinners. They had a notable visit with Mr. Kokichi Mikimoto, famous as originator of cultured pearls. Japan's fine hand industries such as cloisonne, demascene, lacquer, wood prints, and fine textiles were seen in detail. Several major Japanese street festivals were fortunately, if fortuitously, encountered. Other notable experiences of groups included white-water boating on mountain rivers, partaking of the famed public baths of Nabori Betsu, visiting the ancient Ainu tribe, sailing and boating on the scenic Matsushima Bay, visiting a number of Japan's fine shrines, and others. Small Japanese stores and shops, streets, and their people were perennially interesting. Even the transpacific flights, though involving three 10 to 13 hour hops, were not without interest.

The writer believes that he speaks for all of the Mission members in stating that as a professional experience the Mission proved stimulating and satisfying and that as a personal experience it was richly rewarding. The Mission believes that it may have contributed its bit to international understanding and good will.

Appendix

Organization of Engineering Education Mission to Japan

On October 13, 1950, Major General W. F. Marquat, Chief, Economic and Scientific Section (ESS), Supreme Commander Allied Powers (SCAP), wrote former ASEE President Thorndike Saville indicating support for an engineering education mission to Japan. He suggested that fifteen men, covering various engineering fields, spend eight weeks in Japan. President Dawson referred the letter to Dean W. R. Woolrich, as Chairman of the Committee on International Relations of the Engineering College Administrative Council of ASEE. Dean H. P. Hammond agreed to serve as chairman of the Mission, did much of the organization and recruitment of members, then had to withdraw because of unavoidable commitments that developed. The writer at this point accepted the chairmanship.

The Unitarian Service Committee, a nonsectarian, non-political, non-profit, humanitarian agency, accepted responsibility for administrative services under Department of the Army Contract No. DA–49–083–03A–256. Miss Dorothy E. Snavely, Assistant Director of Medical Projects of USC, accompanied the Mission as Executive Officer, caring for all living and traveling arrangements. Dr. B. C. Dees, Chief, Scientific and Technical Division, ESS, and Col. T. R. C. King, Personnel Branch, Office of Occupied Areas, Pentagon, were liaison officers in Tokyo and Washington respectively.

Members of the Mission served without compensation for services, but were paid a *per diem* allowance in lieu of living expenses. The USC-Army contract provided transportation within the United States. Outside the United States travel was under military orders. Food and housing were provided in military billets, actually in the first-class hotels in each area operated by the Army. VIP (Very Important Person) status was obtained for the Mission members, which provided facilities and freedom of action that greatly increased the Mission's effectiveness. Air Force transport within Japan saved several days of working time. Staff-car transport was available on call. Army backing and support was of high excellence throughout. The entire mission was without untoward incident.

Members of the Mission included:

BEESE, CHARLES W. Prof.—Director, Technical Extension Div., Purdue University, Lafayette, Indiana.

BRONWELL, ARTHUR B. Prof.—Dept. of Elec. Eng., Northwestern University, Evanston, Illinois.

CHEDSEY, WILLIAM R. Prof.—Dept. of Mining Eng., University of Illinois, Urbana, Illinois.

CHRISTIE, ALEXANDER G. Prof. Emeritus—Dept. of Mechanical Eng., The Johns Hopkins University, Baltimore, Maryland.

DIETZ, ALBERT G. H. Prof.—Dept. of Building Eng. and Construction, Mass. Inst. of Tech., Cambridge, Mass.

DODGE, BARNETT F. Prof.—Chairman, Dept. of Chemical Eng., Yale University, New Haven, Conn.

DODGE, HOMER L. Dr.—Director, Cabot Fund Program in Aviation, Norwich University, Burlington, Vermont.

FINCH, ROGERS B. Asst. Prof.—Textile Technology, Mass. Inst. of Tech., Cambridge, Mass.

HAZEN, HAROLD L. (Chairman of Mission), Prof. and Head—Dept. of Electrical Engineering, Mass. Inst. of Tech., Cambridge, Mass.

MILLER, ALFRED L. Prof.—Mechanics and Structures, University of Washington, Seattle, Washington.

SAUER, JOHN A. Prof.—Head, Dept. of Engineering Mechanics, Pennsylvania State College, State College, Pa.

STEEL, ERNEST W. Prof.—Dept. of Sanitary Engineering, University of Texas, Austin, Texas.

WALKER, HARRY B. Prof.—Engineering Experiment Station, University of California, Davis, California.

WILKINSON, FORD L. Dr.—President, Rose Polytechnic Institute, Terre Haute, Indiana.

WILLIAMS, ROBERT S. Prof. Emeritus—Dept. of Metallurgy, Mass. Inst. of Tech., Cambridge, Mass.

Summary of Report of the Engineering Education Mission to Japan

Explanatory note: This summary is taken *verbatim* from the report submitted to General Ridgway on 25 August 1951 by the Mission, which is described in the accompanying paper by the Mission Chairman, Dr. Harold L. Hazen. A limited number of copies of the complete mimeographed report (79 pp. + 130 pp. of appendices) are available at Unitarian Service Committee, 31 Union Square West, New York 3, New York.

The appendices include the names of the Japanese committeemen of the Institute for Engineering Education (the Japanese designation for the program of the Mission); the program of sessions of the Mission; list of talks by Mission members to professional societies; list of plant, public works, and university visits; and some of the prepared lectures given to and by the Mission as orientation and summary.

"In accord with its objectives the Engineering Education Mission to Japan has held many meetings in six regions of Japan for exchange of ideas with Japanese engineering educators. Available evidence indicates deep interest on the part of the Japanese and substantial success in achieving mutuality of understanding despite the language barrier.

"Believing that its value must lie in long-term influence, the Mission has phrased its report as well as conducted its sessions, in terms of suggestions based on American experience, rather than in terms of firm recommendations. The Mission believes that real advances must be made by the Japanese themselves in response to Japanese motivation and Japanese conditions.

"Specific suggestions of the Mission that are embodied in this report are the following:

"1. Each individual university should have a large measure of autonomy to develop educational policy and program in response to its special strengths, local conditions, and administrative leadership. The Mission believes that the administrative positions in universities down through department chairmen should be regarded as career opportunities with adequate incentives and responsibilities to assure strong positive educational policies and programs.

"The Mission advocates a large measure of professional freedom for individual staff members, including freedom to do consulting work with personal remuneration. Staff responsibilities should be broadly, not narrowly specified.

"The Mission also advocates a large measure of institutional freedom in fixing the terms and character of faculty appointments. The national public service type of appoint-

ment appears much too constraining to encourage the adequate development of high professional stature in an engineering professor.

"2. Flexibility within each university organization to permit its administration to respond positively and promptly to changing needs and environment is regarded as very important. Such flexibility should characterize the institutional policy for promotion and appointment of staff, for the use of funds within the total amount available to the university, and for all internal operations. The department is the smallest unit, in the Mission's judgment, that should be charged with broad responsibility, if the flexibility necessary to strength is to be achieved. The chair system appears unduly restraining.

"3. The Mission would emphasize closely interrelated teaching and research, rather than research alone as the major function of the university.

"4. Close and personal relations between faculty and students and between faculty members of all ranks are regarded as a very important element in engineering education.

"5. Much freer interchange of students and faculty among institutions and the minimization of 'inbreeding' in faculty are advocated.

"6. The sub-professional level of technical training represented by the former Semmon Gakko is vital to a balanced system of technical education and to a healthy growth of industry. A strongly vocational option in the new junior college is one possible way of providing such training. Another is the use of the former Semmon Gakko facilities to provide sub-professional, evening programs of a terminal character.

"7. Close relations between industry and engineering universities at all levels from student to board of trustees are very important elements of strength in American engineering education. Such close relations would greatly benefit Japanese engineering education.

"8. The Mission recognizes that Japan's engineering universities share the economic difficulties of the country. If Japan is to train the good engineers who will contribute greatly to economic health, she must recognize the inherent costliness of engineering education as compared to education where extensive laboratories are not required, and *find* the money.

"9. Japan's new four-year undergraduate engineering program will fall short a year or more of meeting the technical level of the old engineering degree. American experience indicates that a four-year engineering program is adequate for most engineering students. However, both day and evening graduate work should be provided for the minority of engineers needing more advanced technical preparation.

"10. The Mission strongly endorses the movement to establish an independent Japanese equivalent of the American Society for Engineering Education. Such an organization should greatly strengthen engineering education by bringing together regularly engineering educators and interested industrialists from all over Japan for mutual discussion of common problems.

"11. Japanese engineering libraries appear less widely useful and used than those in the United States where the library is as important an educational facility as the laboratory or classroom. Also, gaps in acquisitions during the past decade, a period of extremely rapid technological advance, are most serious. Freer circulation policies and methods, as well as the filling of serious gaps in holdings, are very important problems.

"12. The Mission believes that Japanese engineering education could benefit greatly by a more widspread use of textbooks and also by the use of the discussion-recitation technique with homework problem assignments. In the United States, hard individual study and work is regarded as the most important element in acquiring the rigorous analytical mental discipline which should be characteristic of engineers.

"13. National taxes imposed on gifts to public and private universities seriously discourage donations by philanthropists and companies. Removal of all taxes on gifts to universities would stimulate private philanthropy and would yield great returns in the further development of higher education in Japan.

"14. Because of the relative newness of many of the educational ideas now being explored and developed in Japanese engineering education, and the inevitable difficulties and discouragements that will occur in such a rapid change, it is suggested that a follow-up, perhaps a smaller mission, might be useful one, two, or three years hence. Such a mission should include some of the present mission personnel plus some new members."

The Engineer—A Parable

By D. B. STEINMAN

Consulting Engineer, New York City

One day three men—a Lawyer, a Doctor, and an Engineer—appeared before St. Peter as he stood guarding the Pearly Gates.

The Lawyer stepped forward first. With confidence and assurance, he delivered a glib and eloquent address which left the Saint dazed and bewildered. Before Peter could recover, the Lawyer slipped him a writ of mandamus, pushed him aside, and strode through the portals.

Next came the Doctor. With impressive bearing, he introduced himself: "I am Dr. Brown," he announced. St. Peter received him cordially. "I feel I know you, Dr. Brown. Many who preceded you said you sent them here. Welcome to our City!"

The Engineer, shy and retiring, had been standing in the background. He now stepped forward modestly. "I am looking for a job," he said. St. Peter wearily shook his head. "I am sorry," he replied; "we have no work here for you. If you want a job, you can try the other place."

This response sounded familiar to the Engineer, and made him feel more at home. "Very well," he said, "I have had Hell all my life and I guess I can stand it better than the others."

Peter was puzzled. "Look here, young man, what are you?" "I am an Engineer," was the reply. "Oh yes," said the Saint, "a member, no doubt, of the Locomotive Brotherhood?"

"No, I am sorry," the Engineer responded apologetically, "I am a different kind of Engineer."

"I do not understand," said St. Peter. "What on Earth do you do?"

The Engineer recalled a definition and calmly replied: "I apply mathematical principles to the control of natural forces."

This sounded meaningless to St. Peter, whose temper was always a bit uncertain. "Young man," he said; "you can go to Hell with your mathematical principles and try your hand on some of the natural forces there!"

"That suits me," responded the Engineer. "I am always glad to go where there is a tough job to tackle." Whereupon he departed for the Nether Regions.

Soon thereafter strange reports began to reach St. Peter. The Celestial denizens, who had amused themselves in the past by looking down upon the less fortunate creatures in the Inferno, commenced asking for transfers to that other domain. The sounds of agony and suffering were stilled. Many new arrivals, after inspecting both places, selected the Nether Regions for their permanent abode. Puzzled, St. Peter sent messengers to visit the place below and to report back to him. They returned, their wings aflutter with excitement.

"That Engineer you sent down there," reported the messengers, "has completely transformed the place so that you would not know it now. He has harnessed the Fiery Furnaces for light and power. He has cooled the entire place with artificial refrigeration. He has drained the Lakes of Brimstone and has filled the air with cool, perfumed breezes. He has bored tunnels through the Obsidian Cliffs and he has flung bridges across the Bottomless Abyss. He has created paved streets, gardens, parks and playgrounds, lakes, rivers, and beautiful waterfalls. That Engineer has gone through Hell and has made of it a realm of industry, peace, and happiness."

A "Year-in Industry" for Educators

By DAVID L. ARM

Dean, School of Engineering, University of Delaware

"Industry has a profound interest in, and responsibility for, contributing to engineering education. The key to quality leadership for our nation and its industries is in the hands of our colleges. To use this key successfully, our colleges must clearly understand their problem, not as it used to be, but as it is today, and as it will be tomorrow."

This statement by Dr. Granville M. Read, Chief Engineer of E. I. du Pont de Nemours & Company, on January 20, 1951, inaugurated a unique program of cooperation between a large and diversified engineering department and engineering education. The occasion was the Second Annual Industry-College Conference sponsored by the American Society for Engineering Education which was held on the campus of the Case Institute of Technology in Cleveland.

Specifically, Dr. Read offered to invite several engineering educators into Du Pont's Engineering Department each year on leave of absence from their regular college duties. He proposed that these educators spend 12 months, not on direct job assignments, but on a schedule taking them through the entire engineering organization. The purpose of the program is to give each participant an opportunity to study, from a top management viewpoint, the organization and operation of a large and complex engineering department.

In order to insure the most effective utilization of the program's benefits, it was decided that invitations would be extended to engineering educators who had wide influence in their respective colleges and who were responsible for the determination of educational policy. Accordingly, those holding positions of Dean, Assistant Dean or Department Chairman in accredited engineering colleges and who take active parts in the activities of professional and technical societies were to be invited to participate.

The program actually began on April 1, 1951, when the writer, who was honored by being selected as the first engineering college administrative officer to be invited to participate, reported at the Du Pont offices in Wilmington, Delaware, to begin his "Year-in-Industry." John W. Whittemore, Associate Dean of Engineering at the Virginia Polytechnic Institute joined the program in July, and Virgil M. Faires, Professor of Mechanical Engineering and Head of Post-Graduation Studies at the Texas A. & M. College, began his participation in August. Since the writer is now completing his year's participation, he believes that it would be timely for an evaluation of the benefits accruing to both engineering education and industry. A number of our leading industrial companies have recognized their obligation to assist engineering education and have sponsored seminars and conferences in which many representatives of engineering faculties have participated. As those who have attended these programs are well aware, the pattern of these efforts varies widely and the time devoted to them ranges from several days to as much as several months. A few industrial concerns hire younger faculty members of engineering colleges for direct job assignments in their engineering organizations for periods ranging from the summer vacation to employment for a full year. So far as can be deter-

mined, however, the Du Pont "Year-in-Industry" is the only program of such comprehensive scope and with as much continuing effort by the sponsoring organization.

Objectives

All programs of the types mentioned have the following common objectives:

1. To acquaint faculty representatives with the sponsoring organization by giving them a broad view of its organizational structure, its activities and its operating problems.
2. To acquaint the participants with the company's philosophies and practices with respect to customers, stockholders, employees and to the community.
3. To make available information about the American business system and how it operates.
4. To make known the educational requirements of the company for potential employees.
5. To give participants an opportunity to learn about careers for graduates with the company or with the particular industry represented by the company.
6. Through discussions, to enable the company to benefit from ideas and observations of the educators.

Activities

During the past year, the writer has had the opportunity of observing the organization and operation of a department whose activities are perhaps more diversified than those of any other engineering organization. These activities range from fundamental research, through the development of special instruments and machines, the complete design and construction of new industrial plants and installation of the equipment, to the rendering of engineering services to plants in full production. In addition, the department conducts its own personnel, training, accounting, and cost estimating functions. It has approximately 3000 people on its salary roll and an additional 35,000 in its construction force which presently is constructing new plants or enlarging existing Du Pont plants at 23 locations from New York to Texas. It has just completed the design, construction and placing in operation of a new cellophane plant for one company and is designing and constructing a complete new plant for the production of nylon for another, both becoming competitors of Du Pont. Also, it is engaged in the design and construction of huge new facilities which will be operated by Du Pont for the Atomic Energy Commission.

Every effort has been made by Du Pont to insure success for the "Year-in-Industry" program. With the exception of classified work being done for the Atomic Energy Commission, no policies, costs or procedures have been withheld from the participants. We have had the opportunity of observing and discussing all phases of the work of the department. We have discussed organizational and operational problems with representative people from the craftsmen in the field and engineers in the offices and the plants to managers of the several divisions of the department. We have spent a considerable amount of time with the construction forces on several different projects. We have been privileged to visit many of the research laboratories and plants and have been invited to attend meetings whose subjects covered the entire range of engineering. We have observed the various specialized training programs and have taken an active part in some. No individual has been told what he may or may not discuss with us, describe to us, or show us. In fact, it seems to us that everything that could have been done to make our "Year-in-Industry" more pleasant and profitable has been done. We have had the wholehearted cooperation, not only of management, but of countless individual workers.

In the 22 years that have elapsed since the writer left industrial employment to enter the engineering teaching profession, many significant changes have, of course, occurred. Not only have products and manufacturing processes changed con-

siderably, but manufacturing tools and facilities have been greatly improved. However, the greatest change for the better, it seems to us, has been in the field of human relations.

Improved Human Relations

All jobs have been made more pleasant, safer, and easier to accomplish with a minimum expenditure of physical effort and with a consequent decrease in fatigue. The worker is well protected against financial crises from accidents and illness and every effort is made to insure his financial independence after retirement. In the event of his death, his family is protected by liberal group plan life insurance. He has the highest standard of living in history with the shortest working hours and unequalled recreational facilities. All these things we have found to be true in Du Pont and we believe that this company is representative of modern industry. As for young engineers, we see unlimited opportunities to travel far along the route of professional advancement and satisfaction.

Benefits

It seems to us that the type of program in which we have been engaged yields the following benefits:

1. Through an interchange of information, both industry and engineering colleges better understand each other's problems.
2. It should make for educational programs better suited to the needs of industry.
3. It should result in better counseling of students.
4. It enables the individual who participates to observe at first hand engineering in action.
5. It creates good public relations both for industry and for engineering education.

The greatest benefits are long-range and perhaps can never be subject to complete evaluation. It seems logical to assume, however, that as more engineering college administrative officers take advantage of such opportunities the benefits to engineering education will increase accordingly. All industry will then be supplied with better trained graduate engineers because of better policies, methods, and philosophies adopted by the engineering colleges. Because we are thoroughly convinced of the value of this type of program in promoting better understanding between industry and engineering colleges, we should like to see more companies follow the lead of Du Pont. The very nature of the program which we have just completed involves a tremendous expenditure of time and effort by the sponsoring organization so that not more than five participants per year could be accommodated by any one company. This leaves much ground to be covered if all accredited engineering colleges are to be given the opportunity of participating in programs of this sort. Since the benefits accrue to all industrial companies, other progressive organizations might well consider similar plans. Since the salaries of the participants, plus reasonable expenses, are paid by Du Pont, the direct financial expenditure is sizable. We have been assured, however, that Du Pont believes that the cost in time, money and effort is well worth while. Certainly, we who are participating are sure that the investment of our time and effort has been well repaid and will reap future dividends.

An Adventure in Engineering Education

By J. TRUEMAN THOMPSON

Professor of Civil Engineering, The Johns Hopkins University

and

W. WORTHINGTON EWELL

Assistant Professor of Civil Engineering, The Johns Hopkins University

This is the story of an experiment which has resulted in a course known as "Library Projects" now included in the Civil Engineering program at Johns Hopkins. The experiment arose from our observation that engineering students cannot write as well as they should, and that the scope of their interests is too limited. Of course no one is to blame for this but their mentors, who, blinded by the importance of their own specialties, have insisted on technically burdened curricula and overcrowded programs.

We had also observed that although the combined libraries of The Johns Hopkins University contain some 800,000 books, and that nearly five hundred engineering undergraduates each day wander contagiously close to these establishments, only an ambitious few are tempted into doing business. Nor is this phenomenon peculiar to the Hopkins campus; it is safe to guess that there are other universities with library stacks left undusted by their engineers.

And even when the typical engineering student does enter a library, he usually does so in order to fulfill a certain need. Unfortunately, self-motivation seldom prompts either his entrance or his need. Almost invariably he is out to gather some facts for use in connection with some technical report or problem, at the insistence of some professor who probably has made the procedure as painless as possible by arranging for the presence of the needed material on the reserve shelf.

And when he has the facts, all too often he presents them in a document that is a far cry from his more carefully written productions of Freshman English. There at least the quality of his writing was criticized—here it is ignored—attention is focused solely on technical accuracy. The plain facts are that very few teachers of engineering care a hoot about the literary value of a report, and not more than a trace of such student papers offer any real opportunity for a display of writing skill.

Evolution of the Course

It took several years of experimentation to evolve the course which is proving so useful and enjoyable to both faculty and students. In its evolution we kept three objectives constantly in mind. First, we felt it was important that our students learn how to use libraries intelligently and efficiently. Next, we believed that nothing we could do for them was of more consequence than to convince them of the importance of being able to write well and to help them to improve their skill. And finally we were sure that as a collateral we would earn their everlasting thanks for the vistas opened to distant horizons by the inculcation of the "library habit."

Lest we be judged presumptuous by our colleagues in our Department of Writing, Speech, and Drama, our library staff, and our readers, let us hasten to say that from the inception of the thought, through its

experimental development and on into its mature application, we have had the advice and cooperation of our friends normally responsible for instruction in writing and in the use and operation of the libraries. One is justified in asking why we did not turn the job over to these professionals, who are admittedly more competent in the field than a staff of engineers. There are two reasons. One had to do with convenience. The complete informality which we held so important to the undertaking demanded that each participant be a member of a small group, say not more than a half dozen, under the tutorial guidance of a faculty member especially chosen for his ability and above all for his interest in the adventure. There are no fixed schedules. The whole class meets not more than a half-dozen times during the year and then only when, at the beginning, plans and intial instructions are being discussed, and at other times when important corners are being turned in the course.

The other reason was based on the belief that it would appear novel to our students to discover that older, more experienced and respected engineers consider the subject of great importance. By contrast, our colleagues in English would naturally be interested in writing and in library research. Faith in this psychology has been amply justified.

As has been stated, one of the objectives of the course is to stimulate an interest in the library through a more intelligent use of its services. How is this accomplished? Since the key to the effective use of any library is found in its reference books, card files, indexes, and bibliographies, the first hours of the course are spent introducing these tools. Thereafter each student spends an hour or more of each week personally ferreting out of the libraries miscellanea of every conceivable sort.

Assignments Varied in Nature

Why should the assignments be so varied in nature? After saturating the undergraduate with a four-year flood of technical subjects, why should the assignments be anything else? Our students know of Castigliano and of his contributions to structural analysis, so they are asked to learn something of Castiglione and his contributions to Italian literature and diplomacy. On the other hand, they may be on intimate terms with Sir Walter Raleigh, while Lord Rayleigh waits to be introduced. But personalities are not the students' concern for long—encyclopedias and biographies yield their information too easily. For the next few hours, they scan the Engineering Index for all of the important articles on Space Frames, or they leaf through the Reader's Guide to Periodic Literature in search of a magazine article entitled "South of Khyber Pass." Rapidly, the assignments become more detailed in nature and the seeker finds himself involved in a multi-phased search. A progressive passage through the World Almanac, The Who's Who for 1900, and the Congressional Record might be necessary to answer the question, "Who was the elder senator from North Carolina in 1900, and what was his most important contribution on the Senate floor during that year?" In all of these initial ventures, the students have only to furnish an answer and to state the source of their information.

As the course progresses, the assignments become more subjective, with the intention of arousing interest in the answer as well as in the search. Delighted with the nonsense answer of the "Holy Bottle," one student read more of the adventures of Rabelais' "Pantagruel." Another student, investigating the subject of "post-inpressionism," was moved to visit the Matisse collection at the Baltimore Museum of Art. And a third, intrigued by his newly acquired knowledge of "The Forms of Music," visited the Music Room of the Enoch Pratt Library in Baltimore, where he listened critically to several recordings to see if he could recognize the difference between the concerto and the symphony and detect the appearance of the cadenza in the former. During this phase of the course, we re-

quire that short essays on the subjects be submitted for criticism.

Ultimately, the real project phase of the course is begun. Calculated to test the students' newly acquired abilities, subjects such as "The Colonization of Africa" and "Bird Life Along the Gulf Coast" are suggested. The freest selection of topic is encouraged, provided that the subject is sufficiently broad in its scope. Written reports on such library projects are rarely successful when they fail to draw from all available library facilities.

Preliminary excursions through the libraries acquaint the student with his selected theme and enable him to make tentative restrictions on the broad topic. Out of the welter of information concerning African Colonization may come a decision to report on "The Transvaal, Former British Colony." Eventually, a preliminary outline on this necessarily restricted phase of the general project is submitted.

Research

After gaining approval on his particular interest, the student is free to proceed with the serious business of research. This follows a series of well-ordered rules. The preliminary brief is developed into an organized outline of the subject and as these ideas coalesce, a working bibliography is gathered together. Next, notes are taken on small cards which permit the expression of only a few ideas directly pertinent to one small portion of the outline. Eventually the student has before him a series of card notes amplifying every item in his outline and a completed bibliography from which he can draw additional information. By this process, he has gained a familiarity with the subject that permits him to write a short but nevertheless bona fide research paper.

The mechanics of the course are simple, allowing a great amount of flexibility. As noted above, the class is divided into groups of not more than a half dozen, and each division is placed under the guidance of a different instructor. Both students and staff members are forced to accept new techniques and view points several times a year under a simple rotational system. In order to supplement instruction by the staff, the text book "The Research Paper," by Hook and Gaver, is used by all class members.

What is Accomplished?

What does this new course accomplish? We believe that it does three things. Of primary importance is the knowledge gained of library facilities and techniques. For those who continue their education in the Hopkins graduate schools, the ability to conduct an intelligent library research is of indisputable value. For those who enter industry, many questions inevitably arise whose answers can easily be found only on library shelves.

Too many engineering students have a disdain of anything that cannot be formularized or converted into practical value. The Library Projects course offers them one last chance to throw off this pall of indifference in which they have been shrouded. In this respect the instruction has been singularly successful. Out of their weekly visits to the library, there comes to most students an awakened interest in things non-technical. Probably because they suffer so badly from an obvious dietary deficiency, engineering students grasp more hungrily than most at fare grown in the garden of words and ideas.

The experience gained in writing the short essays and the final research paper cannot be minimized. There are some who will decry the value of these efforts by claiming that written technical reports produce the same effect. Actually, the effects are not the same, for the efforts that produce them are far from alike. To prove this, one has only to contrast the uninspired efforts put forth on the average technical report with the enthusiastic applications shown in a subject that arouses personal interests. One always writes best and with the greatest ease and enjoyment on a subject of one's own choosing. The

Library Projects course adheres strictly to the principle of free selection of subject matter and in doing so fosters the student's best efforts. The quality of the short essays and the research papers attests to this.

This complex and ever-changing world demands an appreciation of it which is often lacked by members of the applied and exact sciences. And many engineers and scientists will live and die in their own tightly circumscribed little worlds, completely unaware of their lack. Courses like "Library Projects" may help some of them add a little color to the drab fabric of their everyday existence.

Sections and Branches

The 18th annual meeting of the **Southeastern Section** of the ASEE was held at Clemson, S. C. with Clemson College as host on April 10, 11, and 12th.

On Friday morning the meeting was called to order with R. L. Sumwalt presiding. The Chairman introduced M. I. Mantell who presented a paper on "Admission Requirements for Engineering Schools." C. H. Brown followed with a talk entitled "A Program for the Engineering Profession." The third speaker was C. F. Hudgins with a paper on "High School Counseling."

S. C. Hollister, President of the ASEE, discussed "The Critical Shortage of Engineers." Dean Hollister told of the work of the Engineering Manpower Commission and showed how the estimated 20,000 graduates a year were obtained from a total of 800,000 18-year-olds. Dr. Hollister cited the increase in the percentage of engineers to the total labor force and made the observation that the profession has become of age. He cautioned against over-expansion, and stated the need is for more engineers with better training, and not just graduates.

The Chairman next introduced O. Meier who outlined "A High School Guidance Program for Prospective Engineering Students." J. D. Lane spoke on "Science in Our Times."

The following names for officers of the Southeastern Section for next year were presented: Chairman, T. V. Terrell; Vice-Chairman, J. R. Cudworth; Secretary-Treasurer, B. M. Bayer; Representative on the General Council, F. H. Pumphrey (elected in 1951 for two years). A motion was made that the nominations be closed and that the names presented be elected by acclamation. The motion was seconded and passed.

The annual meeting of the **Rocky Mountain Section** of the ASEE was called to order by Section Chairman E. J. Lindahl at the University of Wyoming on April 19, 1952.

H. T. Person introduced the first speaker, W. C. van Dyck, who presented a paper on "Some Present and Long Range Trends in Industrial Recruiting and Training." T. H. Evans gave a talk on "The Moves for Unity in Engineering."

The following slate of officers was nominated and unanimously elected for 1952–53: Chairman, C. A. Hutchinson; Vice-Chairman, A. Diefendorf; Secretary, K. H. Stahl.

The 17th annual meeting of the **Allegheny Section** of the ASEE was held on April 18, 1952 at the Pennsylvania State College. M. M. Boring, Vice-President of the ASEE, was introduced and the other National Officers who could not be present sent their regrets. The following papers were presented: "Improvement of Engineering Teaching," by B. V. Moore; "The Opportunities for Young Engineering Teachers in ASEE Activities," by M. M. Boring; "Pitching and Catching," by J. O. Perrine. The following names for officers were presented: Chairman, C. H. Cather; Vice-Chairman, I. W. Short; Secretary, A. L. Reed. It was moved and seconded that nominations be closed. Motion was carried.

Tests for Engineering College Applicants and Enrollees

By A. PEMBERTON JOHNSON

Project Director, Educational Testing Service

The Pre-Engineering Ability Test, an 80-minute combined half-length version of the two parts of the Pre-Engineering Inventory which are most predictive of 1st term engineering grades, is replacing the *Pre-Engineering Inventory* in a number of engineering colleges. Although the 4-hour Short form and the 6-hour Long form of the Inventory are continuing to be used at certain engineering colleges, the demand for these longer forms appears not to justify their sale after June 30, 1952. Accordingly the general sale of Pre-Engineering Inventory test books will be discontinued after June 30, 1952, although present users who need books can be accommodated.
Answer sheets will continue to be available.

In the same way that the Pre-Engineering Ability Test has replaced the Pre-Engineering Inventory for local use of engineering colleges, the *College Entrance Examination Board tests,* particularly the Scholastic Aptitude Test, has replaced the former National Testing Program of the Pre-Engineering Inventory. The College Board tests, being available at up to 500 centers in the United States and in 20 foreign countries five times a year, are especially useful in evaluating applicants who cannot conveniently travel to the college (s) to which they are applying.

The *College Transfer Test* available at the same times and places as the College Board tests is coming into wider use as a means of evaluating the general ability level of transfer applicants. Use of the Sophomore Engineering Achievement Tests for this purpose and for end of Sophomore year evaluation has declined to the point that sale of test books for these tests is being discontinued June 30, 1952. Sophomore Achievement Test answer sheets will continue to be available.

A new 3-hour Advanced Test in Engineering of the Graduate Record Examinations became available in the fall of 1951 for evaluating a college senior's or graduate school applicant's ability to apply his engineering background to appropriate problems in basic engineering science and in one of four major fields: Chemical, Civil, Electrical or Mechanical Engineering. This test may be taken by individual students or entire senior classes.

Additional information regarding any of these tests may be obtained from Dr. A. Pemberton Johnson of Educational Testing Service, Princeton, New Jersey.

"Winning Teams"*

By ERHARDT C. KOERPER

In Charge of Special Projects Engineering, A. O. Smith Corporation, Milwaukee, Wisconsin

This subject was chosen with emphasis on the "team," rather than on the "winning" because when a good team is intelligently directed there is little question about its probable success. The primary consideration is the team and its membership.

A team can be defined as a group of individuals, each with his specialty complementing the other's toward the accomplishment of common objectives. For the moment, let us give particular attention to the "engineer-technician" teams now working in industry, commerce and science.

Team Characteristics

An effective winning team must first have a worthwhile objective, then inspired leadership with able working members and finally, a persistence born of inspiration. A certain spiritual quality must be present for success, and, if present, will be a guiding light toward worthy and lasting objectives.

Leadership depends primarily on the ideas and ideals of one individual or a very small group of individuals. These personal spark plugs establish the potentialities of the objectives. However, the spark must be transmitted to the working members of the team before leadership is effective.

In every organization there are certain optimum relationships between the specialization of its members. In earlier years, the ideas of an alchemist or inventor were generally embodied by his own hands and he was limited to that extent. At that time our standard of living had not risen to take advantage of many new ideas. Neither was an extra 10 years considered critical in getting a new mousetrap into the hands of the public. That tempo has little place in our life today.

As education became more available to the masses, technical leadership forged ahead. However, with technical specialization there developed a gap between the idea and its embodiment. As this economic waste became more apparent the logical step to overcome it was the training of specialized members who could be effective associates in a "winning team."

Team Work

The teams in industry are not as clear-cut in their organization as are the athletic teams. Neither can the result be so closely associated with any single team.

Our modern, technical teams are made up of engineers, technicians, scientists, and skilled artisans all working together. These are the combat teams of industry, whose integrated knowledge, ingenuity and esprit de corps make possible our technical advancement.

The good things we have of life today come out of thousands of such teams. The steam engine, the automobile, the airplane, television and radar; our power generating plants; the clothes we wear; the gadgets we buy—all these are possible because a large number of specialists have cooperated in focusing their respective abilities toward products for markets.

* Condensed from the annual address at the James H. McGraw Award to Robert Hoover Spahr on June 26, 1951 through the Technical Institute Division of the American Society for Engineering Education at East Lansing, Michigan.

The addition of more adequate training and a better integration of these team members helps go for the greatest possible progress.

Results of Teams

For example, take a pocket watch, originally known as the "dollar" watch. Not for technical reasons it has inflated to $4.25. Without the results of team work we wouldn't even have a vise to hold the watch. The best tool available would be a stone chisel—and of course we would have no steel.

Look at only a fine screw in this watch. It alone required many crews of correlated workers to design the equipment and instrumentation needed for its manufacture.

Thus, steel selling for about 25¢ a pound was transformed into these little screws, selling for at least $500 per pound. This added value was designed into these minute screws and yet the watch weighing about 3 ounces sells for $4.25, or for less than 3 hours wages of the average American worker's time.

Then came the teams that developed, built and maintained the equipment for making it and putting the rest to the watch together, and testing it. In addition there are the modern pioneers who are constanly extending our economic horizons by research for a still better watch at a still lower price.

Fifty years ago a watch of similar accuracy, if then available, would have required 1 to 3 months of the same worker's salary. This value, multiplied no less than 1000 times, is indeed a great tribute to the effectiveness of technical teams.

On the other extreme in weight, we currently mass-produce automobiles which sell in the range of fifty cents to a dollar per pound. This highly complex vehicle is cheaper than beef steak; at present prices even cheaper than hamburger.

Slaves of Society

Early in civilization wealth was often measured by the number of slaves owned. Such slaves working most energetically could only produce at an average rate of less than 1/15 horsepower. The ownership of only a single human slave was the sign of a plutocrat. Where do we stand today on the matter of slave labor?

Now, in comparison, each of us is a millionaire. National averages give each of us about 6 kilowatts of electrical power, or the equivalent of about 100 man power. These electrical slaves are alert, efficient, ever ready to serve our bidding at any time of the day or night, in winter or summer.

Let us pay each of these slaves his current competitive rate. On this basis we would receive the fantastically low rate of 1/10 of a cent per hour. Though difficult to realize, this means that every man, woman and child in our United States has an average of 100 efficient slaves available at a total cost of only 10 cents per hour. Is there any question how we can produce at high rates and maintain high standards of living? Are there any limits to the good we can do?

The significant fact is that all these accomplishments have been made possible through the constant striving of hundreds of effective technical teams working in a favorable economic climate.

International Technical Leadership

Scientific and technical leadership is in international transition. Certain phases of it are moving from Europe to the United States.

For many years the European schools and industries have sent us a rich supply of scientists, engineers, and technicians. This supply of good men, especially of high-grade technicians, has been shut off. Now, lacking that vitalizing source, we must assume the responsibility of adequately training our own team members for technical survival and growth.

In Russia the technical team is recognized as a very effective means for becoming more competitive. Their literature is showing rapid progress in many fields with such teams. We hear that there are between 100 and 300 technical in-

stitutes behind the Iron Curtain. For comparison we have perhaps 50, of which only about half are accredited. As for size, the overwhelming chances are that the Russian counterparts are considerably larger than ours.

Economic Climate

Even though we need many more technical teams, those we have tend to be more effective than those of our totalitarian competitors because of four very important and basic factors which help define our economic climate.

We should know more about these factors, not only to take fuller advantage of them, but also to preserve their inherent virtues for the individual against the inroads of indifference and false security. These factors, are our:

1. Competitive system of free enterprise which rewards the individual on a basis of his productivity.
2. Personal productivity is multiplied through the intergration of specialized personal abilities.
3. Mass demand for products is maintained by high take-home pay for individual productivity.
4. Patent system encourages equitable reward and keeps invention competitive for the good of the public.

Ratios of Team Members

The winning team in industry, has changed its shape and activity over a period of time. It continues to change.

The pioneering Spahr-Wickenden report of 1929 showed that such teams were made up of about three technicians for each professional member. About 14 years later another basic report, in which Mr. Spahr was again a major contributor, showed an average of about five technicians for each professional member.

The difference between these two figures was caused in part by the addition of the distributive industries in the latter report, and in part to the increasing use of technicians since the first-mentioned report. In some industries where servicing and installation is high, the ratio now goes up to 11 technicians for each professional member.

Currently, the number of qualified technicians graduating as compared with the engineers graduating is in the ratio of approximately one to one. If the spade work is to be done in ratios ranging between 5 to 11, to each professional member we must ask the question, "Are we keeping technically abreast of competition?"

Technical Institute Progress

This Division is progressing soundly on the basis of established fact and analysis. These have included: 1) analysis of Technical Institute type of curricula, 2) a study of the jobs of Technical Institute graduates expressed in the same basic terms used to describe individuals, and 3) constant upgrading of academic quality through curricula accrediting by ECPD and course approval by NCTS.

Objectives

The following major objectives will help in building and utilizing winning technical teams:

1. Establish a clearer understanding of the nature and function of the technician. Until this is undertood their utilization will only be a small fraction of what it should be.
2. Dignify the term "technician" or its substitute. Both the technician and the engineer, as well as management need to recognize their mutual interdependency.
3. Develop closer contacts with industry in order to better train technicians as well as to encourage their broader utilization. The technicians' education is unique and should not be deviated by either trade school or college educational objectives.
4. Give students better counseling which is based on facts about jobs as well as individuals.

In Appreciation

Those in industry who see the serious problem of developing winning technical teams appreciate and hold in high regard the efforts of the Technical Institute Division of the American Society for Engineering Education and are anxious to work with you. Already you have made great strides of progress. You still have broad, fertile fields to clear and to cultivate. I know that you will continue to be increasingly successful.

College Notes

Plans for dedication of the new Metals Processing Laboratory at the **Massachusetts Institute of Technology** on Tuesday, June 3, have been announced by Dr. Thomas K. Sherwood, Dean of Engineering at the Institute. The dedication program will be followed on June 4 and 5 by a two-day technical conference on metal cutting which will feature speakers of national reputation in the metal cutting field.

Dedication exercises for the new building, made possible by a gift of $1,000,000 from Alfred P. Sloan, Jr., Chairman of the Board of General Motors Corporation, will include a presentation address by Mr. Sloan and an address of acceptance by M. I. T. President, Dr. James R. Killian, Jr.

Recent developments in Aeroelasticity will be reviewed in a special course to be given from July 14 to July 22 during the 1952 Summer Session at the **Massachusetts Institute of Technology.**

The program has been designed for both the practicing aeroelastician and the engineer in related fields. General topics will include Introduction to Aeroelasticity, Aerodynamic Tools of the Aeroelastician, Theoretical Solution of Practical Aeroelastic Problems, and Dynamic Models and Wind-Tunnel Testing.

The appointment of John E. Dean to be professor of electrical engineering and head of the electrical engineering department at **Colorado A & M College** is to be effective August 1, 1952.

Admiral Edward L. Cochrane, head of the Department of Naval Architecture and Marine Engineering at the **Massachusetts Institute of Technology** since 1947, has been appointed Dean of the School of Engineering.

Admiral Cochrane succeeds Dr. Thomas K. Sherwood, Dean of Engineering since 1946, who has asked to be relieved of the administrative duties of the dean's office to devote full time to teaching and research in chemical engineering, in which he has been a member of the faculty since 1930.

How Can Industrial Training Aids be Adapted for Classroom Use?

By JOHN GAMMELL

Supervisor of Sales Training, Allis-Chalmers Mfg. Co., West Allis, Wisconsin

The education and training that engineers receive in college is continued by industrial companies that employ them. Unlike colleges, employing companies can use an economic yardstick in measuring the usefulness and effectiveness of education and training. It is largely for that reason that industry has turned to training aids as a means of speeding up, and in some cases, improving the learning processes. Training aids make it possible for industry to train more men quickly and to conserve the time of skilled instructors as well as the time of the trainees.

It is felt that some industrial training aids may be used in modified form by colleges and universities as teaching aids. The author would like to discuss some of the visual training aids used by the Allis-Chalmers Manufacturing Company which are considered typical of industry.

Industrial training aids, generally, fall into two categories: job training and sales training. Sales training also includes those materials which are actually used as sales tools by field salesmen. Job training aids are of little value to colleges since they are usually of limited scope, treat specific instances rather than principles, are built around the rules and practices of a specific company and are planned for a relatively untrained mind. Sales training aids and sales tools, on the other hand, may often have a high value to the engineering school.

Industrial Films Available

There is one other instrument of learning which does not properly come under either of the above headings, but which may be available to colleges. Occasionally scientific investigations conducted by industrial companies are done in such a way that the experiment is, in a sense, reproduceable in the classroom. Most companies are happy to supply prints of films (for example, where the work is not a government or commercial secret) at cost or less.

The form in which these materials are available varies depending on the purpose for which they were prepared. One of the most common materials, of course, is motion picture film. Almost every company of any size has one or more motion pictures of their products which may have some interest and value for the engineering student. Many companies also have slidefilms, both silent and with sound, which are particularly valuable as teaching aids because of their adaptability. Some companies supply their salesmen with various types of scale models or schematic devices to illustrate the principles of the machine or product which the company manufactures. Most companies would probably be glad to order extra units and sell them to colleges at cost or less.

It is recognized that most of these materials are not designed in such a way that they can be used in classrooms without some modification. Many of them are

pitched at too low an audience intelligence. Many of them go into commercial details which are not of importance to the college student or for which he does not have time. However, adaptations can be made. These aids can be edited at the colleges with little student assistance. Others can be edited at the source.

For example, if a college instructor saw some individual frames in an Allis-Chalmers color slidefilm on centrifugal pumps that he was able to use in his own work, the Company can furnish that material in many forms. It can furnish the complete film with record. It can furnish a print of the film only, which can be cut and spliced in any way desired. Commentary can be added by either speaking directly or using a tape recorder. Editing sound motion pictures is a little more difficult since the sound track is not on the same section of film as the picture which accompanies it.

Large print in color or black and white of any single frame or frames from the film can be furnished. These can be used for lectures or for bulletin board material. Photographic prints up to 16×20, and on occasion larger, of any photographs in the company's sales literature or files can be supplied. If, in a design class, an instructor wants to discuss a pump design as it actually is done by one commercial firm, a large copy of a cutaway drawing may prove helpful.

It seems that many of the commercial angles involved in manufacturers' training aids should not be objectionable from the academic point of view. The students will go out to live in a commercial world. Where commercial practice can be combined with the theoretical material, the result is not detrimental, but actually beneficial.

In the News

The National Science Foundation has announced approval of 41 research grants, totaling $406,660, in the biological and physical sciences. This is the second group of research awards to be announced this year under the Foundation's program for the support of basic research, bringing the total number of announced Foundation research grants to 69. Additional proposals are being evaluated by the staff of the Foundation with the help of advisory panels of outstanding American scientists. Grants in this group were made to institutions in California, Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, Oklahoma, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Vermont, Wisconsin, and Hawaii. The research fields included are biochemistry, biophysics, chemistry, comparative physiology, developmental biology, endocrinology, engineering, enzyme chemistry, experimental plant biology, genetics, microbiology, oceanography, physics, pharmacology, and systematic biology.

The duration of research grants in this group ranges from 1 to 5 years, with an average length of 1.8 years. The average grant amounts to $9919 per year. The research grants were approved by the National Science Board upon the recommendation of Dr. Alan T. Waterman, director of the Foundation.

Let's Really Get Back to Fundamentals*

By H. I. TARPLEY

Professor of Electrical Engineering, The Pennsylvania State College

When teachers of engineering subjects assemble, sooner or later their talk will turn to curriculum building. This was never more evident than in the deliberations of local ASEE institutional committees appointed this year to study teaching techniques in their own colleges, and universities. Try as they might, committee members were never able to divorce their discussions on teaching techniques from curriculum revision.

Objectives of Engineering Training

Any discussion of technical options in electrical engineering undergraduate curricula must first consider objectives. Too often a local curriculum will be built around the interest of staff members with a lamentable disregard to the students' needs. What are the simple objectives in the training of any student engineer? They have been competently set forth in a statement by Warren K. Lewis, "Our objective is the development of the capacity of the student when faced with a new and unfamiliar situation, to handle it with competence involving skill, initiative and leadership. . . ."

A curriculum that succeeds in attaining the foregoing would be considered ideal by anybody, and must give a broad fundamental training to our engineering students.

Options in Engineering

Since fundamental physical principles and methods of engineering analysis in mechanical engineering, electrical engineering, chemical engineering, civil engineering, industrial engineering, aeronautical engineering, etc. are identical, why all these options? Most institutions set up all of these engineering options years ago, solely in the interest of thoroughness. Some few colleges still feel that these are unnecessary, and accordingly have eliminated these options.

Options in Electrical Engineering

Why was it necessary to further subdivide each, for example, electrical engineering into the technical options, Electronics, Communication, and Power? The same principle that led to subdivision of the engineering curriculum as a whole was followed in setting up electrical engineering technical options. It was caused again by the desire for thoroughness.

To raise the question as to how successful the system of options in electrical engineering is at the present will cause an unending argument among the various teachers. However, a few weaknesses will be admitted by anybody. First, no electrical engineering option is any better than the sum total of the technical courses constituting that option. Therefore, the weaknesses of options are inherent in the various technical courses which have too often become "hardware" courses. The rise of an electrical "gadget" to economic importance has been the signal for a new "hardware" course to be crowded into one of the electrical engineering options as a technical course. Often these are more descriptive to the student than not, and offer little fundamental training that is

* Paper delivered at Annual Meeting of ASEE in East Lansing, Mich., June 25–29, 1951.

worthwhile in the long run. The carry-over of fundamental principles of analysis between these "hardware" courses is disheartening to behold. Each of these courses, even in the same option, often plough the same "ground" over and over in the hope that some few "grains" of common fundamental analysis will remain with the student. Some of the better students recognize and remark at the duplication of effort, while the average student is never aware that there is much relation between the various courses at all. That there is much truth in the foregoing observations is supported by the rapid increase of the number of colleges and universities that have found it necessary to insert into their electrical engineering curricula a course in engineering analysis in order to attempt a correlation of courses. Let nothing be said here to detract from a successful course in engineering analysis.

The use of "hardware" in a course should be only for the purpose of bringing to the fore the use of fundamental principles applied to a sample engineering problem.

The chief weakness of subdividing electrical engineering into the electronic, communication and power options lies in the fact that the division has been made solely on the basis of "hardware." The student is easily led to "glorify" the hardware of his special field; he cannot evaluate the true significance of any fundamental principles used because his focus is on the "hardware." He can only learn, in many instances, a few formulas that may be used in the solution of some few typical engineering problems.

Is it possible for a teacher of a technical option course to compensate for such weaknesses by a meticulous pointing out of fundamental analysis and principles as they are used? Of course good teaching techniques will help. On the other hand, the teacher cannot easily, by any teaching technique, take the student's focus from the "hardware" because of the restricted area with which an option deals. The student does not therefore, gain a broad background in fundamental principles as most options are organized.

Why have the engineering options, mechanical engineering, electrical engineering, civil engineering, etc. been relatively more successful when compared to the sub-options of the electrical engineering curriculum? The answer lies in the fact that the former options are *not* made on the basis of "hardware" alone, but on a more fundamental basis of principles. Whether engineering was divided consciously into options on the basis of fundamental principles is immaterial. The fact remains that electrical engineering has been subdivided consciously into options on the basis of "hardware."

The present option scheme in many electrical engineering curricula has equipped students with an inadequate narrow background, that has not fitted them to cope easily with the problems of engineering. There are many signs of this inadequacy. One of the most distressing is the difficulty of finding young instructors with a sufficiently broad background to teach the undergraduate stem courses. Many are indignant if asked to teach a laboratory stem course in power machinery when they are products of a communication option. Their training included such a diluted presentation of power machinery that they are incompetent to teach even the most elementary courses involving power machinery.

There are alternatives which can overcome some of the objections to the common existing technical option program.

Improved Option Programs

For those of us that feel the option program has merit, the most pressing need for improvement requires, first, as much liberalization of the choice of option technical courses as possible, coupled with a sincere attempt to organize those technical courses into broad fundamental courses that do not focus the attention of the student unduly on "hardware." It is unnecessary to attempt to analyze all the

principal "hardware" of a given field, since such analyses should serve only as examples.

Option programs ought to permit a student to select technical courses that are considered definitely "out of bounds" in many present option programs, in order to broaden his fundamental background. At once, the cry will go out that to permit a student some personal choice of technical courses contrary to an outlined option program would only destroy the option. The answer to that is obvious; if it would, the option program ought to be destroyed! Any student's choice of elective technical courses outside the prescribed option program may be safely guided by his adviser. The student would feel a personal responsibility for his program when he had cooperated with an adviser in its planning.

Conclusions

1. To give a more fundamental training to electrical engineers, option programs must be liberalized as much as possible to permit a choice of technical courses by the individual student. The fewer the number of prescribed technical courses in a given option, the better.

2. The professional technical course must use the "hardware" of a given field only as examples to which emphasized fundamental principles are applied.

Reserve this date . . . .

June 22-26, 1953

ANNUAL MEETING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA

Science and Public Relations[1]

By JOHN I. MATTILL

Secretary, Engineering College Research Council; and Assistant Director, News Service, Massachusetts Institute of Technology

When the House of Representatives first cut 98% from the appropriation requested for the National Science Foundation for 1951–52, its members are said to have reasoned that the United States cannot afford the luxury of "unproductive" fundamental research at a time when practical results are so desperately needed by the Military.

Later this nonsense was repudiated; the cut in National Science Foundation funds was partially restored, to $3.5 million of the $14 million first wanted, by the Senate and House in conference. But the skirmish proved once more how little is known among laymen—even in high places—about the ways and needs of science. "Apparently the men and women of science and technology must undertake a broad program of educational research in Washington," said *Chemical and Engineering News*.[2]

Scientists have already cut their teeth in the business of persuading fellow citizens to their methods and achievements. The very existence of the National Science Foundation proves the success of one of the scientists' initial efforts and the form of today's Atomic Energy Commission is still more eloquent evidence.

Engineers, though they shared in setting the stage for the National Science Foundation, have made a lesser beginning in the job of telling laymen about their profession and its significance.

This is the job of public relations, including a multitude of activities whose goal is their single unifying common denominator. These activities share one other characteristic: all have special implications for *administration*, because responsibility for them begins there.

What public relations may mean to engineering research administrators was given brief attention before the Engineering College Research Council at East Lansing, Michigan, in June, 1951. If the four papers given there could only scratch the surface of a very broad subject, the summarizing which follows necessarily multiplies this inadequacy.

The story begins with an unusually effective informal definition of public relations by an outstanding professional counsel. It ends with a sharp warning from the director of one of the most effective public relations organizations in American science. In between is the more practical "how to" side of the story from two of its practitioners in leading engineering schools.[3]

[1] A summary of four papers presented before the ECRC in East Lansing, Michigan, June, 1951.

[2] Vol. 27, No. 38 (Sept. 17, 1951), p. 3789.

[3] Both were at the time members of the first National Publicity Committee of the American Society for Engineering Education, of which Richard W. Schmelzer of Rensselaer Polytechnic Institute was chairman. As a result of this group's work in publicizing the 1951 Annual Meeting, a Public Relations Committee has been established as a permanent function of the Society; Mr. Schmelzer continues as chairman.

What the Other Man Thinks of You

"Public relations began," said Allen Will Harris,[4] "when God or Charles Darwin created the first two persons on this earth. It became increasingly important when the third person was born. And it is not entirely a joke to suggest that the fourth person was a public relations expert, amateur or professional.

"What I am stating is simply that Man, Man's attitudes, Man's relations, Man's need for communication, are the basic business of public relations. The goals are equally simple: to help create a healthy, attractive personality, based on sound policies and real accomplishments, and to attract maximum favorable attention for that personality in order to increase its effectiveness.

"A shorter definition is this: public relations is anything you do that affects what another man thinks of you."

A definition in somewhat different form came from James W. Armsey,[5] who said, "Public relations means doing a good job and getting recognition for it. It means building a good reputation through good character. In any enterprise, and particularly in education, it means making sure that the public is served and that it knows it is served."

The breadth of public reltaions by these definitions suggests that some of its aspects have a way of turning up in almost every executive act.

"Since policies flow from top management and activities result from policies," Mr. Harris continued, "the major responsibility for public relations cannot be delegated 'down the line.' Sound public relations requires top management to put the factor of what-the-other-man-thinks into each equation confronting it. The weight accorded to the factor will vary with the nature of the problem, but the factor must always be included in decision-making."

To many engineering research administrators this may seem the addition of a new and very foreign dimension to their problems. But in another sense, public relations is only a formal expression of much that is in the realm of "common sense" to every good administrator. Thus, Mr. Harris went on, "Public relations is a *total* activity, touching upon all phases of the organization's life, from personnel recruitment to morale, turnover, pay, job security, patents, legal activities, community relations, guests, contract-getting and contract-keeping, relations with Government, public information, security, contacts with the professional societies, and so on, endlessly. Secondly, public relations has a passion for facts, the subjective facts of opinion and attitude. Thirdly, public relations seeks to remedy what is wrong, prevent further conflicts or failures, and encourage the healthy and effective portions."

"The essence of public relations is knowing the importance of what the other man thinks and feels," said Mr. Harris, taking pains to emphasize both the breadth and subtlety of the problems thus implied.

"Since many of you make the decisions which underlie your organizations' public relations, let me briefly suggest what might be called the public relations process for reaching a decision:

1. Determine accurately the objectives of the decision.
2. Determine in detail all of the routes to these objectives.
3. Determine the needs and attitudes of the person or groups necessary to the success of the decision.
4. Determine which of the routes to your objectives will fulfill the largest number of needs and cross the smallest number of attitude obstacles.
5. If the obstacles seem grave or even insurmountable, honestly and care-

[4] Public Relations Counsel, 229 West 42nd Street, New York 18, New York.

[5] Then Director of Public Relations, Armour Research Foundation and Illinois Institute of Technology, Chicago 16, Illinois; now Assistant to the President, New York University, New York 53, New York.

fully consider the possibility of changing your objectives.

6. If the objectives are the only possible objectives and if no new route is practicable, be sure to state the full reasons for your decision clearly when you communicate it. Most persons will put aside their opinions and try to make your ideas work if you give them the full, frank and honest facts.
7. No matter how small the decision may be, accept as a major premise of your administration that the decision *must* be sold and *resold* and the consequences of the decision subjected to periodic evaluation.

"These steps, modified and adjusted to the specific case, as all general systems must be, can do an amazing amount toward the elimination of old problems and the aborting of new problems. This is a practical approach, well tested and proven in a host of organizations of the first rank.

"The choice facing you is not a choice between public relations and no public relations, but between deliberate, organized public relations and accidental public relations. You need not worry about the cost of organized public relations; the cost is almost always smaller than that of an accidental, unorganized activity."

Policy-Making in Public Relations

Mr. Armsey carried these concepts to the more specific questions facing college and university research administrators. Research, he said, adds a complication to the traditional responsibilities of educators to students, parents, teachers, and the public from which (directly or indirectly) comes their support. Through its effect on all these, research adds a new complication, too, to public relations.

Research affects the budget, forcing adjustments of costs and salaries. It affects personnel—including factors of availability, qualifications, personal interests and desires, and personnel management methods. The main responsibility of an educational institution is to students, and research can affect their college experience. A fourth set of problems arise in connection with public service responsibilities: local research needs of industry may not be entirely consistent with the best interests of an educational program. "One of the pesky things that cuts across the lines of responsibility to your students, the public, and yourself is the general problem of classification and publication," added Mr. Armsey.

"All of these questions are part of the total policy-making aspect of your public relations program. I have purposely stressed them because the effectiveness of the other two aspects of public relations are dependent upon what answers you arrive at. That is, you can't hope a) to do a good job, or b) to get credit for it, unless by your policy decisions you create an atmosphere in which a good job can be done.

"Your first big public relations problem is to realize you have a public relations problem. That's not easy. Your contract research, like your teaching, or like any other activity in today's society, cannot be done in a vacuum. It is subject always to critical scrutiny by several publics, or segments of the so-called general public. And education, despite its wide acceptance as a worthwhile enterprise, finds its critics numerous and vocal."

"The truth is," Mr. Harris had earlier said, "that research organizations, indeed all scientific organizations and technical groups present some of the most difficult problems to be found in the public relations field." He listed four worthy of special consideration:

1. Security regulations prohibit normal communications among scientists, between organizations and their communities, and between science and the lay public.
2. The time scale of major research is dangerously misunderstood; the public is being led to a terrible disil-

lusionment because of the gap between what can be done and what self-promoters claim for scientific endeavor.

3. Increasing amounts of research are dedicated to developing materials of destruction; will a revulsion from war presently stigmatize scientists as "merchants of death?"
4. No species is more difficult to organize and manage than the modern scientist.

Policies and Procedures

All of these problems, said Dr. Lisle A. Rose,[6] raise fundamental questions of setting up and conducting a public relations program for our research activities. Why a *program?*

"The answer is plain and simple: to aid in doing effectively and economically what all of us do every day whether we know it or not, like it or not—that is, give information to a large number and variety of people and leave impressions of our worth with them.

"Since we are necessarily engaged in public relations, it seems prudent to engage intelligently—with foresight, with coordination, without stumbling and fumbling and waste. It seems prudent to get the most possible benefit for ourselves and give the most possible benefit to our publics with the smallest feasible cost in effort and money. This means planning. It means a program."

The kind of program depends on many factors, Dr. Rose said. Many have been mentioned already; in addition, he listed the number and nature of an organization's audiences, its sponsoring and cooperating agencies, policies established by outside and inside agencies . . . all must be fitted into the overall concept guiding the character of public relations.

These research and public relations policies must vary from institution to institution. But, according to Dr. Rose, "four obvious Policies about Policies ought to be universal. First, policies governing research and public relations ought to be rational in view of *all the circumstances* in which the administrators, the research men, and the participants in the public relations program find themselves situated. Second, everybody should understand the what and why of the policies. This is one function of any public relations specialist whom the research organization may utilize. Third, the policies ought to be reviewed frequently—with account taken of such intangibles as tradition and even to some extent personal desires and preferences. Last, policies that don't stand up under review should of course be modified or replaced."

What about the public relations specialist? He soon becomes an important part of this story, Mr. Armsey had earlier noted. "Once you have recognized that you have public relations whether you like it or not, and you have decided that you should actively operate to make your public relations good, your next step is to get a good public relations director, or, if you already have one, to utilize his talents to the fullest.

"His biggest value to you is his advice and counsel in helping you steer a sound administrative course that will result in getting a good job done and in getting you proper recognition for doing it. He can do his job best if you keep him informed, consult him often, and work cooperatively with him."

For the director and his public relations staff, the rub comes with specific problems. "We don't always do and say the right things," Dr. Rose admitted. "But we must try to anticipate the occurrence of problems, not find ourselves suddenly stuck with them. We must bring in on our decisions the judgments of a number of men, not just the supervisor of a research project or the Director of Public Relations or the Director of Research. And to guide our decisions, I repeat, we must have well-defined policies,

[6] Director of Information and Publications and Experiment Station Editor, College of Engineering, University of Illinois, Urbana.

based on well-defined purposes and on continuous analyses of our publics."

This kind of public relations program, Dr. Rose said, is eminently justified—and in fact necessary—for an institution supported mainly by taxes. "People will not long pay for something whose worth they do not believe in. For expediency's sake, then, if nothing else, the value of research and its relative inexpensiveness ought to be set forth." The same argument applies, with only slight variations, to privately financed institutions.

But, continued Dr. Rose, there is a higher, less selfish reason as well. "None of us carry wings; but we all try to fill a beneficial social function. Most of us try to give more service than we're paid for. So we ought to volunteer certain kinds of information and translate other kinds voluntarily into common terms that the layman grasps."

Public Relations is a Vital Obligation

The results of present-day public relations activities for and by science are promising, said Dr. Walter J. Murphy.[7] "We believe," he said, "that science has been sold quite well to the American public—a development for which we of the American Chemical Society News Service take some credit. But we do not think our task has been completed."

"Science today is intimately interwoven into the fabric of everyday living," Dr. Murphy pointed out. Research has resulted in many grave problems which now have become the subject of public discussion, and the progress of science is dependent upon political decisions which rest ultimately with the public. "It now becomes our duty and responsibility to see that the American people are properly educated on the scientific aspects so that decisions they do make are sound," he said.

"We now have a National Science Foundation. We have the problem of finding continued financial support from private sources for fundamental research and for our institutions of learning so that the overall support will not be entirely governmental in nature. We have the grave problem of the proper utilization of our scarce scientific and technical manpower in a period of international uncertainty. We have the problem of encouraging more of our youth to enter the learned professions, particularly the physical sciences and engineering. We have a great problem of educating the American public to the fact that we can no longer depend upon foreign sources for much of our pure and fundamental research.

"How this country meets these and other equally great questions over the next decade will mean the difference between a democratic or totalitarian life for hundreds of millions. The future of America is wrapped up in many of these questions. Today when I talk to you about public relations, it is these questions that are uppermost in my mind. These are the challenges that we must meet; these are the responsibilities that we have created for ourselves. Frankly, I must admit at this particular moment, we are poorly equipped to cope with our obligations.

"Call me an alarmist if you will, but I warn the scientific, technical, and professional societies of America that, unless they undertake immediately a broad program of education concerning science and technology and their implications to the man on the street, disastrous decisions will be made by the citizens of this country on matters of life and death importance. Democratic processes function properly only when the electorate is fully informed on the questions they are asked—yes, required to decide. This is a responsibility and an obligation that we of the learned professions cannot disregard."

[7] Director of the American Chemical Society News Service and Editor of *Chemical and Engineering News* and *Industrial and Engineering Chemistry*, 1155 16th Street, N.W., Washington 6, D. C.

TIMELY TIPS

A Note on the Validity of the Pre-Engineering Ability Test

By ROLAND C. MOORE

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The Pre-Engineering Ability Test (2) was offered in 1951 as a "short, inexpensive, easily administered and readily scored test" providing "a predictive effectiveness estimated to be . . . as high as that for the composite score on the Pre-Engineering Inventory." The present note deals with the extent to which this estimate of validity has been confirmed in a situation of actual use of the test.

The Pre-Engineering Ability Test was administered to all freshmen entering the College of Engineering and Science at the Carnegie Institute of Technology in September 1951 during the initial week of the term. At the close of the semester the correlation was calculated between total scores on the Pre-Engineering Ability Test,* and student "factors" (weighted averages of course grades) earned for the first semester work. The correlation sample consisted of 260 students, after exclusion of those who did not complete a semester's work, those with previous college work, and those with foreign language handicap. The correlation coefficient resulting was .68. This value stands up well in comparison with validities of the Pre-Engineering Inventory Composite Score for first term average grades as reported for various schools (1) and is not lower than correlations obtained at this institution in previous years between the PEI Composite Score and "factor" at the same point.

A further comparison is possible in that Pre-Engineering Inventory Composite Scores were also available on 57 of the students in the present sample. For this group, characterized by PEA Total Score mean and standard deviation quite similar to those of the parent sample, the correlation between PEI Composite Score and factor was .75, and that between PEA Total Score and factor was .73. Here, of course the absolute magnitude of the coefficients is of less significance than their close correspondence.

These findings thus support the view that the objectives of providing a shorter, more convenient test without sacrificing the predictive power of the longer test have been attained, and that no less confidence accrues to the PEA Total Score than to the PEI Composite Score in situations appropriate to the use of the PEI Composite Score.

* PEA Total Score Mean is 50.5, and standard deviation 13.07. All correlations given are significant beyond .01.

REFERENCES

1. LORD, F., COWLES, J., AND CYNAMON, M. "The Pre-Engineering Inventory as a Predictor of Success in Engineering Colleges." *J. App. Psychol., 34*, 1, pp. 30–39 (1950).
2. *Manual, Pre-Engineering Ability Test*, Educational Testing Service, Princeton, N. J. (1951).

A Double Integral

A Visual Presentation

By E. A. WHITMAN

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The slide film, "A Double Integral," was prepared for classroom use. The captions are intended to give the required explanations though the author prefers to accompany the slide film with his own comments, the latter being adjusted to the needs of his particular class in calculus. No accompanying recording has been made as it would appear likely that this slide film, and the others with which it forms a set of films on integration, would be used largely by instructors who would desire to make their own comments. As the teaching of calculus falls more and more into the hands of inexperienced instructors it may become desirable to use recordings.

It is assumed that the reader is interested in the *whys* and *hows* of slide films such as this rather than in the subject matter presented. Each frame is a photographic representation of a drawing by the author. These drawings, the captions and the accompanying equations, yes, even many of the numbers and separate letters were made separately and pasted on a sheet. This is a great advantage over trying to put everything on one sheet and gives a chance to arrange and rearrange to improve composition. Generally the drawings project better if the photographer prepares negative slides, thus having the words and lines appear in white on a black background.

Slide Film Supplements Text Book

In the subject of integration, the slide film is of particular use as a supplement to the text book. Many drawings are needed, too many to be included in a textbook. Each figure serves a limited purpose, yet a definite one in showing how an element of an area is changed as certain changes are made in an arbitrarily chosen length. There is not one big or complicated drawing that can show the whole mass of details since some blot out others.

This need for many drawings in the story of integration is in contrast to a complicated figure of a machine—say perhaps some drawing with which an instructor is experimenting preparatory to inclusion in a text book. Yet with such a drawing it might be well to consider a slide film in place of a single drawing, with each frame prepared to show an added detail. Successive pictures at various stages of the construction of such a building as a new summer camp tell more about the work of making such a building than does a picture of the finished product.

On this slide film the need for successive drawings really begins as we consider the column formed by adding several small elements of area, each a rectangle, one above the other. The calculus may require that one take the limit of the sum of the equal rectangles as the altitude becomes smaller and smaller but the number of rectangles is increased. A word description is difficult yet a set of some six to ten figures shows why it is that the limit of the columns is one definite column for a particular area no matter by what law we decrease the altitudes. The usual rectangle and column of a text book presentation leaves many students without any idea of the process. This process of summation must, in double integration, be repeated on the columns to cover the area. The essence of this slide film lies in showing, by a set of drawings, how an area bounded by curved lines is the limit of the summation of a set of rectangles. On

seeing this, the finding of that area is not merely a routine application of a formula out of a book.

This particular slide film has some added frames, for a second presentation to a class, showing limitations on the process, and modifications for particular circumstances. While these latter can be shown very well by black board figures the film gives the opportunity to use figures drawn at leisure.

While this film has been published a glance at the catalogue in which it is listed shows how very meager is the offering in slide films for subjects at the college level. It has been the experience of this author that publishers are quite willing to take considerable risks in publishing. What seems to be needed is teachers who are willing to prepare the necessary drawings and captions. At present the demand, at the college level, is not such as to give prospective authors much hope for monetary rewards. But the growth of that demand is in our hands.

College Notes

In preparation for completion of **Howard University's** new School of Engineering and Architecture building and facilities before September, 1952, the largest piece of new equipment, a new Baldwin testing machine of 600,000 lb. capacity was installed. This is part of a $2,000,000 expansion program of the School of Engineering and Architecture.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Pennsylvania State College	April 18–19, 1952	E. B. Stavely, Pennsylvania State College
Illinois-Indiana	University of Illinois	May 17, 1952	D. G. Ryan, University of Illinois
Kansas-Nebraska	University of Nebraska	Nov. 16–17, 1951	Kenneth Rose, University of Kansas
Michigan	University of Detroit	May 10, 1952	W. P. Godfrey, University of Detroit
Middle Atlantic	Villanova College	May 10, 1952	S. J. Tracy, Jr., City College of New York
Missouri	University of Arkansas	April 5, 1952	R. Z. Williams, Missouri School of Mines
National Capital Area	Howard University George Washington University	February 5, 1952	W. Oncken, Jr., Bureau of Ordnance
New England	Worcester Polytechnic Institute	Oct. 18, 1952	E. T. Donovan, University of New Hampshire
North Midwest	Iowa State College	Oct. 3–4, 1952	S. J. Chamberlin, Iowa State College
*Ohio	Ohio State University		W. F. Brown, University of Toledo
Pacific Northwest	University of Washington	April 25–26, 1952	T. H. Campbell, University of Washington
Pacific Southwest	California State Polytechnic College	Dec. 29–30, 1952	S. F. Duncan, University of Southern California
Rocky Mountain	University of Wyoming	April 19, 1952	E. J. Lindahl, University of Wyoming
Southeastern	Clemson College	April 10, 11, 12, 1952	R. L. Sumwalt, University of South Carolina
Southwestern	University of New Mexico	April 3 & 4, 1953	H. P. Adams, Oklahoma A. & M. College
Upper New York	Alfred University	October 10–11, 1952	R. M. Campbell, Alfred University

Members of the Society are welcome at all Section Meetings

* No Date Set.

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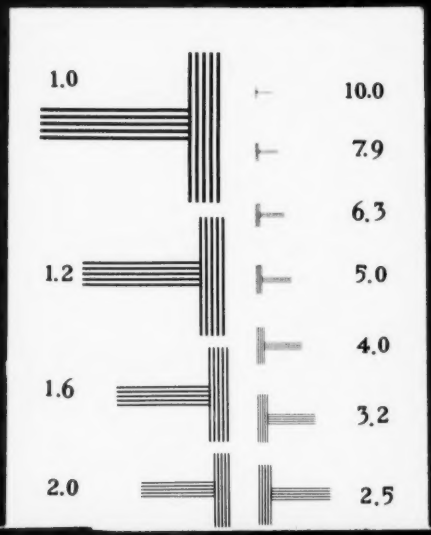
RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.

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